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ABSTRACT

Through discussion and a test of theoretical models, the need to consider nutrition in development planning for rural areas is addressed, and the complex interaction of agricultural and food policies on family nutrition is described. Chapter I indicates the extent and types of malnutrition and discusses both the relationship of nutrition to development and the influence of economics on nutrition. Producer and consumer oriented economic policies, as well as approaches which explicitly include nutrition factors early in the policy planning process, are discussed in Chapter II. Chapter III assesses suggested methodologies for determining the nutritional impact of policies. Methodologies considered include input-output models, nutritional deficiency indexes, food consumption theory approaches and nutrient consumption approaches. Chapter IV proposes an equation suggested by household production theory and tests this equation on data from the United States. Along with a model for total nutrient consumption, models for illustrating the effects of home-produced food on consumption are considered. Regression results from the models put forth in the previous chapter are discussed first on a variable by variable basis (income, employment of the homemaker, education, race, adjustment for extra meals eaten, and family classification) and are then examined in terms of the models as a whole. Conclusions are drawn from the models and their performance, and from the general analysis of nutrition's role in economic development. (Author/RH)

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NUTRITION IN POLICY PLANNING FOR THE RURAL SECTOR

by
Patricia M. O'Brien Place

Cornell International Nutrition
Monograph Series
Number 8 (1981)

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PREFACE

This Monograph differs in some respects from the others in the Series in that it is not focused on a particular problem nor on one geographic area, and it uses data from the United States rather than that from a developing country. The Monograph addresses the need to include nutrition in development planning and attempts to describe the complex interaction of agricultural and food policies on family nutrition.

The author discusses methods that can be used to discern the nutritional impact of various policies. The nutrient consumption approach is chosen as a descriptive model of the socioeconomic variables that influence nutrition. The analysis is based on rural data from the 1965-66 Household Consumption Survey of the United States.

The Monograph suggests that the nutrient consumption model is useful as a descriptive tool in nutrition planning for development. It appears that this approach may be relevant for use in other countries and other situations. It is for this reason that the Monograph appears in the International Nutrition Monograph Series.

The author in the early chapters reviews and discusses the relationship of nutrition and economics, and the importance of nutrition in economic planning. These chapters have relevance both to industrialized and to non-industrialized countries.

The Monograph is based on work done by the author for her Master of Science degree in Agricultural Economics at Cornell University. Part of it was undertaken while she was doing research on nutrition and economics at the World Bank in Washington, D.C. Patricia O'Brien Place is currently doing a Ph.D. in agricultural economics at Cornell.

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Table of Contents

	Page
CHAPTER 1. INTRODUCTION--NUTRITION AND ECONOMICS	1
Extent and Types of Malnutrition	1
Nutrition and Development	8
Economics and Nutrition	10
CHAPTER 2. AN OVERVIEW OF NUTRITION IN ECONOMIC PLANNING AND POLICY	12
Producer Oriented Policies	14
Consumer Oriented Policies	17
Integrating Nutrition into Planning	23
CHAPTER 3. SUGGESTED METHODOLOGIES TO DETERMINE THE NUTRITIONAL IMPACT OF POLICIES	28
Nutritional Objectives and the Allocation of Resources	28
Nutritional Deficiency Indexes	30
Food Consumption Theory Approaches	31
Nutrient Consumption Approaches	35
CHAPTER 4. THE METHODOLOGY AND DATA	46
Form of the Equations	46
Family Size-Composition Variable	47
Other Socioeconomic Variables	52
Modeling Home versus Purchased Nutrients	52
The Models	55
The Data	56
CHAPTER 5. RESULTS AND CONCLUSIONS	63
Income	63
Employment of the Homemaker	74
Education	74
Race	75
Meal Adjustment	75
Family Classification Variable	75
The Models	79
Conclusions	80
BIBLIOGRAPHY	82

CHAPTER 1

INTRODUCTION--NUTRITION AND ECONOMICS

The urgency of nutritional problems in developing areas has been expressed by nutritionists for some time. In recent years, professionals of other disciplines have come to the realization that nutritional problems in most countries will not be eliminated by present development strategies (60,68). The problem of how best to integrate nutritional goals into development policy depends upon how these policies affect nutrition. These effects are not always clear nor easy to prove to those in control of policies. Therefore, methodologies for determining the effects of food and agricultural policies on nutrition are of considerable importance. The most complicated policy interactions occur in the rural sector, specifically amongst subsistence (or semi-subsistence) farmers.[1] Precisely because of its difficulty, the rural sector has been ignored in the few methodologies developed to date.[2]

Within the area of integrating nutrition into the planning and thus policy process, this monograph will concentrate on the position of rural subsistence farmers. The process whereby development policies might effect their nutritional status will be described. Secondly, the methodologies available to elucidate the nutritional status of groups of people and possibly describe the impact of policies will be outlined. Thirdly, one methodology useful in the first stage of the policy process (description of the problem) will be illustrated. Before these three objectives can be pursued, a general description of the nutrition problem, its extent and types, is given for those economists unfamiliar with nutrition. A general overview of nutrition and the economics of development is given for the same purpose.

Extent and Types of Malnutrition

Malnutrition is an all-encompassing term that practically needs redefinition with each usage. It can include obesity as well as starvation. In this study malnutrition is defined as one of two possibly concurrent manifestations:

i) undernutrition -- the lack of sufficient food;
ii) deficiency -- an inadequate amount of one or more essential nutrients.

Undernutrition can in general be described by the gap between available and necessary calories, although protein and water consumption are also

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1 Subsistence farmers are those who obtain all or most of their food from their farming efforts. Semi-subsistence farmers are borderline, in that they either have a small off-farm income or are able to make slightly more than a bare living from their farm.

2 Much work is currently being done to formulate research approaches to this problem (see 20,37).

major factors. To survey for malnutrition on an individual basis is time-consuming and expensive. Therefore, to indicate the numbers likely to be malnourished within a given country or area more aggregate measures are typically used. Since such measures are general, they are much less reliable than nutritional surveys for clinical signs of deficiencies and undernutrition.

Available calories per capita can be derived from analysis of the content of food available at the retail level. These figures can be compared with a per capita requirement determined on the basis of the age-sex distribution of the country[1] to obtain a rough indicator of the nutritional situation. A recent example of this type of estimate appears in Table 1.1. It shows mean calories per capita to be insufficient in all of the developing world. Since we cannot necessarily assume these calories to be equitably distributed, the energy per capita should be at least 110% of the requirement per capita, in order to ensure that each individual will probably receive this bare minimum (11:250). These figures are meant only to provide a rough estimate of the relative (by area) nutritional problem in the world. The aggregate nature of these statistics makes them invalid for most other uses.[2] The percentages of calories obtained from vegetable and animal sources indicate the much higher ingestion of vegetable products, which are more likely to be low in protein, in the developing areas.

Before proceeding to discuss nutrient deficiencies, a word is necessary about nutrient "requirements" or standards, usually known in the United States as RDAs (recommended dietary allowances). As defined by the National Research Council, "Recommended Dietary Allowances are the levels of intake of essential nutrients considered, in the judgment of the Food and Nutrition Board on the basis of available scientific knowledge, to be adequate to meet the known nutritional needs of practically all healthy persons."[3] RDAs are not actual requirements of individuals, rather they are estimated to exceed the requirements of most individuals so as to ensure that the needs of most are met. Specifically, they will not necessarily meet the needs of people who are not healthy, i.e. infection or other disorders may increase needs for certain nutrients. Allowances will also vary with body size and sex, physical activity, climate, age, as well as physiological state. Appropriate uses of RDAs include planning and procuring food supplies for population groups, interpreting food consumption records in relation to assessment of nutritional status, guidelines in establishing policy for health and welfare programs, nutrition education, and nutritional surveys as they relate to government policy (39). The fact that an individual's intake is below the RDA is not

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1 For further description of this process see (67).

2 Andre Van Veen, guest lecturer, Nutritional Sciences 680, Cornell University, Fall 1976.

3 National Research Council, Food and Nutrition Board, Recommended Dietary Allowances, 8th edition (Washington, D.C.: National Academy of Sciences, 1974), p. 2.

TABLE 1.1: Energy & Protein Supply by Region

Region	Energy				Protein		
Region	Total calories per caput 1974	Estimate[a] % of per caput RDA from 1969-71	Product Source[b] (% of total)		Total grams per caput 1974	Product Source[b] (% of total)	
			Vegetable	Animal		Vegetable	Animal
Developed	3334	131	66	34	95.4	41	59
N. America	3492	133	58	42	103.9	32	68
W. Europe	3412	134	68	32	93.7	44	56
Oceania	3355	127	60	40	100.6	34	66
Other	2852	121	82	18	84.9	54	46
Less Developed	2194	96	92	8	54.1	79	21
Africa	2117	91	94	6	52.7	82	18
L. America	2558	106	84	16	65.5	61	39
Near East	2465	101	90	10	65.5	79	21
Far East	2063	93	94	6	49.2	85	15
Centrally Planned	2674	c	83	17	75.8	68	32
Asian	2329	99	91	9	63.7	80	20
Eur-USSR	3513	149	71	29	105.3	50	50

SOURCES: World Food Conference, Assessment of the World Food Situation Present and Future (Rome: United Nations, 1974): p. 57, table 9.

United Nations, Food and Agriculture Organization, 1976 Production Yearbook, vol. 30 (Rome: United Nations, 1977): pp. 243-245, 246-248, tables 97, 98.

[a]These were estimated from RDA per caput for 1969-71 (figured from Assessment of the World Food Situation Present and Future) and total calories per caput 1974.

[b]These percentages were derived by the author from the FAO tables.

[c]Estimate is unavailable.

a definitive indicator that he is deficient. However, when the number of such individuals is high and/or the situation persists for some time, the risk of deficiency in the population is increased. All dietary surveys need clinical nutritional surveys to substantiate the existence of deficiencies. Important additional information can come from biochemical determinations and anthropometric measurements.

Table 1.2 provides a list of dietary standards from several countries for adult males and females. They vary due to different views on what allowance is required to ensure adequate nutrients for "most" of the population, differing climates, and differing average physical size of populations. Another factor that causes them to be so disparate is the fact that much debate still exists amongst nutritionists as to exactly what quantity of certain nutrients is really needed.

Protein-calorie malnutrition (PCM) is the most prevalent form of malnutrition in the world (68:9). Figure 1.1 is a simplified representation of the spectrum of PCM: its general type and prevalence. PCM is a two dimensional continuum from normal to clinically diseased children and from mainly a lack of protein to mainly a lack of calories. The percentages indicate the probable amount of children in each category in some typical malnourished areas. In general, the only children to appear clinically malnourished are those 3 to 5 percent at the tip of the "iceberg" of PCM, but if that percentage is visible then there are in all likelihood many more in the moderate to mild range. Infant and toddler mortality rates and deaths from infectious diseases such as measles can be used as indicators of those in the middle categories because the synergistic effect of malnutrition and disease usually results in the death of the child from what normally would be "non-fatal" diseases.[1] Malnutrition in some form contributes to 50% or more of the deaths of children in LDCs.[2]

Calorie deficiency is the most severe and pervasive amongst children. This is largely the result of two possibly interacting factors: the child is given insufficient food, or the food contains too much bulk or water for the child to be able to eat a sufficient amount of it at two or three meals in the day. Vegetable sources of calories are more bulky and lower in calories per serving than most animal products. Thus, areas where calories are derived largely from vegetable sources (as shown in Table 1.1) are more likely to have malnourished children. Calorie deficiencies in children tend to begin to occur around 6 months of age when breast milk alone is no longer sufficient or when insufficient milk formula is being given to the child. If allowed to progress, nutritional marasmus will develop, which even if cured (the fatality rate is between 12% and 40% with hospitalization[3]) can have permanent stunting effects both mentally and physically. Even if it does not progress to the point of marasmus there may be permanent physical, if not mental effects.

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1 See Latham's analysis of nutrition and infection (29) for further description of this phenomena.

2 Latham, Nutritional Sciences 680, 9/21/76.

3 Ibid., 9/9/76.

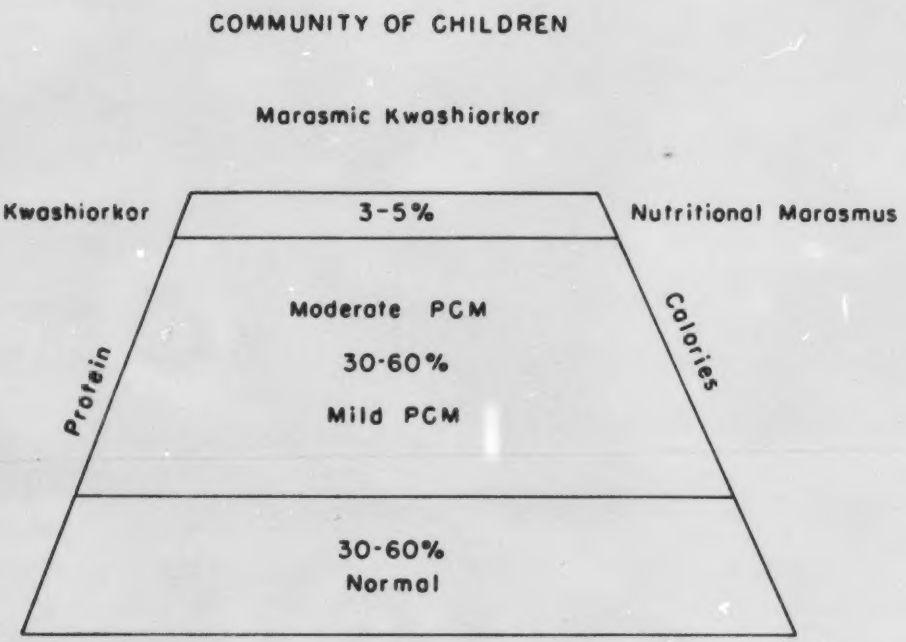
TABLE 1.2: Comparative Dietary Standards of Selected Countries and UN Agencies[a]

COUNTRY	SEX	AGE (years)	WEIGHT (kg)	ACTIVITY	ENERGY (Kcal)	PROTEIN (gm)	CALCIUM (gm)	IRON (mg)	VITAMIN A ACTIVITY (IU)	THIAMIN (mg)	RIBOFLAVIN (mg)	NIACIN EQUIV. (mg)	VITAMIN C (mg)
U.S.A.	M	22	70		2800	65	0.8	10	5000	1.4	1.7	18	60
	F	22	58		2000	55	0.8	18	5000	1.0	1.5	13	55
FAO	M	25	65		3200	46	0.4-0.5		a	1.3	1.8	21.1	
	F	25	65		2300	39	0.4-0.5			0.9	1.3	15.2	
Australia	M	25	70	a	2900	70	0.4-0.8	10	2500	1.2	1.5	18	30
	F	25	58		2100	58	0.4-0.8	10	2500	0.8	1.1	14	30
Canada	M	25	72		2850	50	0.5	6	3700	0.9	1.4	9	30
	F	25	57		2400	39	0.5	10	3700	0.7	1.2	7	30
C.A. and	M	25	55	Moderate	2700	65	0.45	10		1.1	1.6	17.8	60
Panama	F	25	50	activity	2000	60	0.45	10	a	0.8	1.2	13.2	50
Colombia	M	20-29	65	Moderate	2850	63	0.5	10	5000	1.1	1.7	13.8	50
	F	20-29	55	activity	1900	60	0.5	15	5000	0.8	1.1	12.5	50
France	M		65	Moderate	3000	90							
	F		55	activity	2400	75							
India	M	25.4	55	Moderate	2800	55							
	F	21.5	45	activity	2300	45							
Japan	M	26-29	56	Moderate	3000	70	0.6	10	2000	1.5	1.5	15	65
	F	26-29	49	activity	2400	60	0.6	10	2000	1.2	1.2	12	60
Netherlands	M	20-29	70	Light	3000	70	1.0	10	5500	1.2	1.8	12	50
	F	20-29	60	activity	2400	60	1.0	12	5500	1.0	1.5	10	50
Norway	M	25	70	None	3400	70	0.8	12	2500	1.7	1.8	17	30
	F	25	60	given	2500	60	0.8	12	2500	1.3	1.5	13	30
Philippines	M	None	53	Moderate	2400	53	0.5		5000	1.2	1.2		70
	F	Specified	46	activity	1800	46	0.5	a	5000	0.9	0.9	a	70
S. Africa	M	None	73	Moderate	3000	65	0.7	9	4000	1.0	1.6	15	40
	F	Specified	60	activity	2300	55	0.6	12	4000	0.8	1.4	12	40
U.K.	M	20 up	65	Medium	3000	87	0.8	12	5000	1.2	1.8	12	20
	F	20 up	56	activity	2500	73	0.8	12	5000	1.0	1.5	10	20
U.S.S.R.	M			Moderate					5000	2.0	2.5	15	70
	F			activity					5000	2.0	2.5	15	70
E. Germany	M	18-35		Light	2700	85	0.8	10	5000	1.6	1.5	18	70
	F	18-35		work	2300	75	0.8	15	5000	1.4	1.3	15	70
W. Germany	M	25	72	Sedentary	2550	72	0.8	10	5000	1.7	1.8	18	75
	F	25	60	activity	2200	60	0.8	12	5000	1.5	1.8	14	75

Source: National Research Council, Food and Nutrition Board, Recommended Dietary Allowances, 7th edition (Washington, D.C.: National Academy of Sciences, 1968): pp. 69-71.

[a] See original source for extensive notes on primary sources and unavailable data.

FIGURE I.I. THE PROTEIN - CALORIE MALNUTRITION "ICEBERG"



Insufficient protein, in the extreme case, particularly for children one to three years of age, may result in kwashiorkor. Kwashiorkor (according to one accepted definition) means the disease of the displaced child. It was so named because it usually occurs when a new child is born and the older child is displaced as the most immediate concern of the mother. Kwashiorkor also tends to coincide with weaning and a switch to reliance on the generally inadequate protein in certain vegetable staples. There may be sufficient protein if the staple is eaten in large amounts, but not enough available on a percent by weight basis for a child. The fatality rate of kwashiorkor is high, and the possibilities of complete recovery depend on how acute or chronic the malnutrition has been. A child who has had chronic malnutrition before developing kwashiorkor is likely to be physically stunted.

Protein is utilized for three primary functions: building of new tissues, upkeep of old tissues, and as a basis for enzymes and other metabolic functions in the body. It has a secondary function of providing energy. When energy intake is sub-optimal then part or much of the protein may be used for energy. An apparently adequate intake of protein can hide an actually insufficient utilization rate, in that protein may be burned up as calories before it can be otherwise utilized. Protein requirements per capita are complicated not only by the age-sex-income distribution of the population, but by the quality of the protein generally eaten. The quality of protein depends on the distribution and content of its amino acids which in turn is largely dependent on its source. Animal proteins are often more complete in their amino acids, whereas vegetable proteins need to be derived from several sources to achieve the same balance of amino acids.

In past decades, the emphasis in nutritional problems has been on the "protein gap" or lack of sufficient protein supplies in LDCs. However, this obscures the more basic problem of low calorie intakes. If the recommended calorie intake is met, using mixed cereal based diets, in general the recommended protein intake will be achieved in the process (49:9). The major exceptions to this are populations which depend heavily on low-protein staples such as cassava. An emphasis on increasing protein supplies which generally yield fewer calories per acre, can actually be to the detriment of a population if calorie availability is marginal.

Other major deficiency problems as stated by the World Health Organization[1] are:

i) xerophthalmia: vitamin A deficiency resulting in blindness especially in children--most prevalent in Southeast Asia;

ii) endemic goitre: iodine deficiency resulting in an enlarged thyroid gland and possible cretinism--occurs all over the world especially in highland areas where there is less iodine in the soil and therefore the crops grown there;

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1 Latham, Nutritional Sciences 680, 9/21/76.

iii) nutritional anemias: iron and/or folic acid deficiency resulting in low work performance and decreased humoral immunity--affects predominantly pregnant and lactating women, and young children on poor diets worldwide. It may also be secondary to parasitic infections such as hookworm.

These deficiencies can all occur despite sufficient calorie intake. In general, sufficient meat or fish in the diet will help prevent severe nutritional anemias because heme iron from these is better utilized than that from vegetable sources. In general, this will not affect vitamin A or iodine deficiency. Iron and β-carotene (a precursor of vitamin A) are present in good amounts in dark-green, leafy vegetables. The latter is also available in most yellow or orange vegetables. Iodine is found in many food items in trace amounts, but the amount of iodine depends on the iodine content of the soil. Certain foods from the sea are rich in iodine.

Estimating the per capita requirement of nutrients other than calories is quite difficult. The issues include:

i) nutritionists often disagree about requirements per day per type of person for some nutrients;

ii) given a different nutrient requirement for every type of person (by sex, age, etc.) the method of aggregating into a per capita general requirement leads to serious errors with nutrients that are needed only in minute amounts (milligrams);

iii) with certain nutrients such as protein and iron the amount in the diet may be less important than the quality or the source of the nutrients.

Therefore, calorie requirements per capita and availability (if possible by income group[1]) are all that can easily be considered on a "per capita" basis.

Nutrition and Development

Historically, nutrition has been considered to have three different relationships to development (43). First, it was thought to be a problem that would automatically be solved by the process of development. When it became clear that malnutrition was still severe and perhaps exacerbated by development efforts, a second phase in which the economic consequences of malnutrition were emphasized came into vogue. Soon it was apparent that this relationship was not clear cut and more emphasis was placed on the contribution of nutritional well-being to national welfare and hence to development. Granted, not everyone has progressed through all of these phases, and many still proselytize for each viewpoint. A reasonable approach appears to be

1 See (49) for a description of calorie estimates per capita by income class.

to consider nutritional factors as indicators of the welfare of the people of a country. For low-income peoples the basic necessities--food, shelter, and clothing--form the major proportion of their budget. Therefore, the use of nutritional status as one indicator of food consumption can be considered an indirect measure of the social welfare particularly for lower income peoples (25). In other words, nutritional indicators can give the economist one more tool to analyze the redistributional aspects of various agricultural policies (43:107) affecting rural subsistence peoples.

If development is interpreted to mean improvement in the welfare of the majority of people in underdeveloped areas, then the nutritional impact of policies can indeed be a powerful tool. Two problems are encountered in attempts to implement such a definition of development. First, is the situation of a government officially committed to "development" which in reality is unwilling to act for the betterment of the majority of the people (i.e. the low-income groups). For this set of nations it is doubtful that this analysis will be useful unless they can be convinced of the long-term political necessity of incorporating the poor into the socio-political system.[1] Another tactic could be to educate them in the economic costs of malnutrition in the process of development (6, 32), however, these are generally unsatisfactorily authenticated. Research in the area of direct economic effects of malnutrition is where nutritionists can make a contribution by providing "indicators of need" which will lead to quantitative estimates of the effects of policy alternatives (25: 5, 54).

Secondly, even with a valid political commitment to improving the situation of the poor, confusion exists as to how best to achieve this (10). Without an empirical analysis of the effects of policies governments may be reluctant to implement an appropriate course of action. Their existing policies may appear more effective for long run development, and thus more effective (from their viewpoint) in eradicating malnutrition. This follows from the idea that nutritional well-being is not a goal of development planning, but a problem of underdevelopment. In illustration, a quote from a senior official in a Middle East country is "We are a very poor country. We can't afford luxuries like 'nutrition'. We have a more basic problem--just to produce enough food."[2]

In the past, the nutritional impact of development policies has generally been ignored (70:11). An example is the emphasis in such policies and typified by the "green revolution", of increasing the food supply without adequate consideration of the problem that the ability to buy food is in short supply, not food per se. Many

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1 However, it could be useful to international agencies with which these countries have contact.

2 Greaves, "A Conceptual Approach to National Nutrition Program Planning: General Discussion" in Alan Berg, et al., Nutrition, National Development, and Planning (Cambridge, Massachusetts: MIT Press, 1973) p. 301.

variations in the nutritional effects of government policies have been noted ex post facto. Land reform is generally considered a good basis for decreasing rural poverty and hunger. However, in the case of Kikuyuland in Kenya there is evidence that land reform coupled with agricultural extension policies has increased cash crop production to the detriment of both the farmers' nutrition and overall food production (56). Two illustrative quotes from the study are:

> Nutrition is inadequate in Kikuyuland. This is the direct result of policies which, although well meaning, have failed to view rural development, and especially food production, as a total system rather than a series of disparate elements. If this situation is to improve, agricultural policy will need to be reviewed in the light of the changing political, economic, social, and technological situations...

and

> It can be argued with some validity that the increased wealth obtained from the cash crops will be used by the people to improve their diet, given adequate nutritional education, but success depends upon the products necessary for dietary improvement being readily available to the people. Agricultural development so far has led to the establishment of a marketing structure totally geared to the export of agricultural produce (from Kikuyuland). No comparable structure exists for food import.[1]

A study on agrarian reform and its nutritional results in Peru (43) has also found no clear improvement in nutrition, and probable deterioration. In this case the ancillary effects of an increased exposure to infections, increased inequality in the distribution of food, and increased population were unforeseen problems of the reform. Developments in seemingly non-nutritionally related items such as roads can hurt nutrition by providing the means to send food away to urban markets at the expense of on-farm and rural community consumption. Sometimes production of cash crops is encouraged while ignoring that the time involved in producing those such as rubber can preclude the production of a viable level of food for the farm family (50). In summary, there is a need to include nutritional goals or evaluate nutritional consequences in the development planning process.

Economics and Nutrition

Starting from the premise that food in sufficient amounts to all people is a basic right, as expressed in the World Food Conference resolutions[2], and that most malnutrition is not being eradicated by

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1 D. R. F. Taylor, "Land Reform in Kenya: A Reappraisal," Rural Africana 23 (1974):88.

2 See reference (64) for the resolution and reference (65) for follow-up of such.

present development programs (49), what can economists do? There are three options for interfacing nutrition and economics:

i) to ascertain the direct economic effects of malnutrition;

ii) to use nutrition as a tool to measure the welfare effects of policies;

iii) to integrate nutrition goals into development planning.

Direct economic effects can be explored through the sort of studies that have largely been done by nutritionists in the past. These vary from clinical studies on the biochemical effects of PCM, to field attempts to measure the effect of iron supplements on work productivity, to measuring calories burned in pursuing agricultural labor.[1] The findings so far are inconclusive as to the permanent effects of malnutrition,[2] but numerous on-going effects have been documented. Some of these are stunted physical development including smaller brain size; psychological effects, such as apathy in PCM children; decrease of stamina and life-spans; and the synergistic effect of malnutrition and infections leading to increased deaths from common illnesses.[3] All of these result in lowered productivity through decreasing the ability to absorb education while young and shortening the working life. When one considers the amount of unemployed in the less-developed countries (LDCs) it may not seem economically important to worry about their level of productivity (9:22). It is necessary to recognize, however, that investment in human capital is as important for future development as investment in physical capital because the demand for skilled labor should increase with development. Of more consequence would be the increase in the productivity of the self-employed. By breaking the vicious circle of poverty-poor nutrition-low productivity through an improvement in nutritional status, it would allow an end to the situation.

It is generally agreed that if the incomes of the poorer groups in less-developed areas were to increase, most of the nutritional problems would disappear. The problem lies in choosing appropriate policies that will have this effect on the most-disadvantaged groups. Since these groups generally spend over half of any increment in their income on food (35:72), their nutritional status and changes in such are indicators of whether income policies are reaching them. A relevant question would seem to be why not just look at changes in their income? The answer is two-fold:

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1 See the works of S. S. Basta (3, 4) for research on the relation of iron and productivity. See the work of T. T. Poleman (46) for some basic research on calorie usage in agricultural production.

2 See the works of Cravioto (2), Barnes (17), and Latham (30) for a discussion of whether PCM has permanent physical or psychological effects.

3 See Latham and Latham (31) for an intriguing work on the economic and nutritional implications of ascaris infection.

i) this says nothing about how the prices of and availability of food are actually affecting consumption; and

ii) when working in rural subsistence farming areas the imputation of prices and incomes can be very complicated.

If one uses nutrients to aggregate the food available to a household, then the problem of imputed prices and incomes is largely avoided. This is not to say that prices and income are unimportant nor that the usual price and income effects should not be calculated, but rather that nutrients can give their own unique perspective on the food situation of peoples by income levels.

In the development policy process the economist recognizes certain objectives for which she must determine relevant policies. Nutrition can and should enter this process as either an objective or a constraint on the objectives of agricultural policies. To do this necessitates prior analysis of economic policies to determine their probable effects on the nutrition of the populace. At the very least, nutrition should enter the process as another variable, descriptive of the rural subsistence farmers' situation.

This monograph addresses the integration of nutrition into policy and planning. Chapter 2 discusses the specifics of policy interactions on the nutrition of subsistence farmers in an attempt to illustrate the need for explicit consideration of nutrition in the choice of policies. The planning process is outlined with particular reference to the inclusion of nutrition goals. Chapter 3 presents methods of describing the nutritional situation of groups of people. Some of these methods are capable of giving a rudimentary idea of the nutritional impact of policies. Of the methods presented in chapter 3, the nutrient consumption model is chosen to illustrate its descriptive capabilities. Chapter 4 summarizes an application of this model to data on the rural South of the United States in 1965-66.

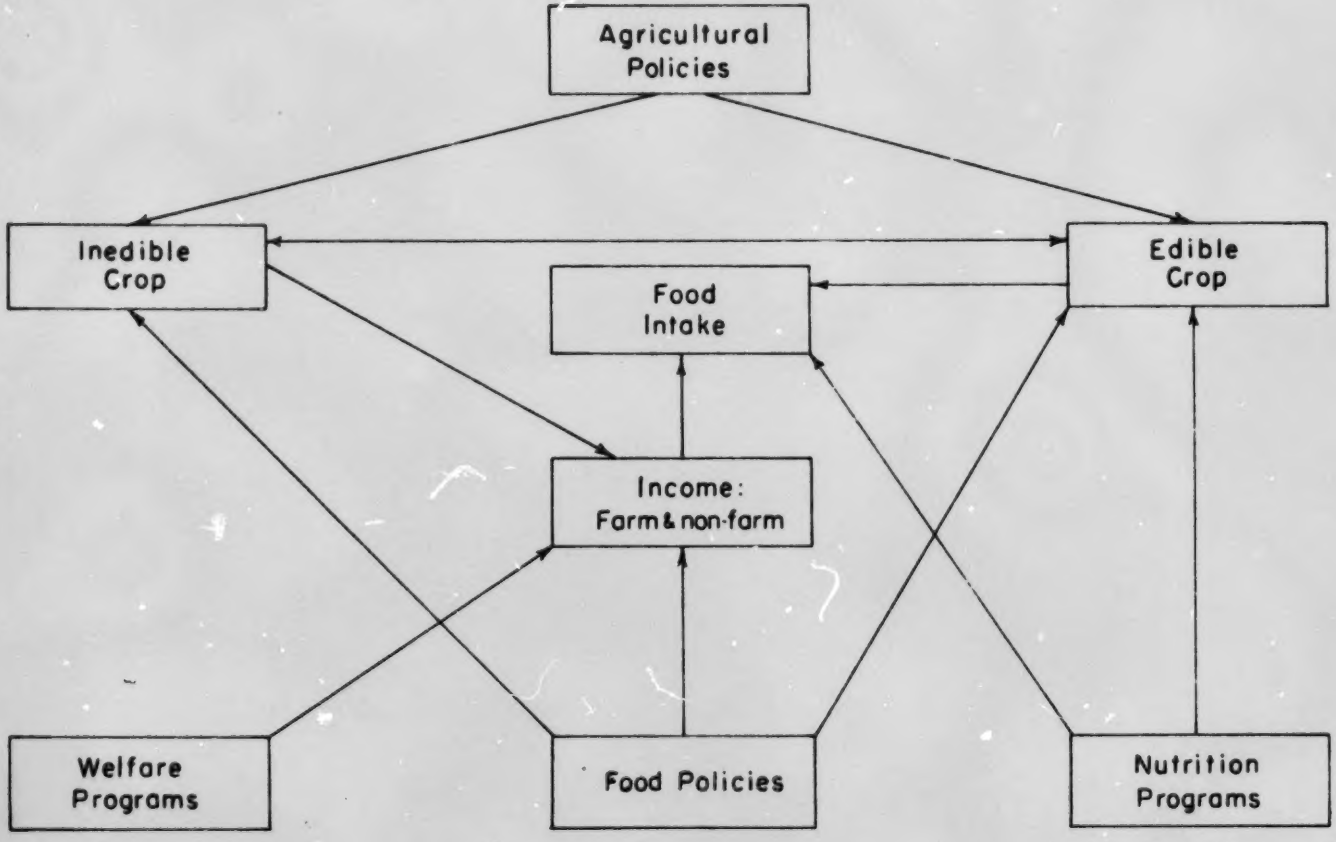
CHAPTER 2

AN OVERVIEW OF NUTRITION IN ECONOMIC PLANNING AND POLICY

The inclusion of nutrition in economic policy and planning is not simple. Policies from many areas--health, agriculture, nutrition, food--all converge in such a way as to have a total effect on the nutrition of a population while obscuring the individual effects. To illustrate this problem, one of the more complex cases, that of the subsistence farmer, will be discussed in detail. This leads into a discussion of the general planning process and the role nutrition can play before the policies are made.

Farmers, at or near subsistence level, are in a dual position with respect to food and agricultural policies. They are producers as well as consumers, and a policy which might be good for one can be bad for the other. Figure 2.1 is an attempt to illustrate the

FIGURE 2-1. AGRICULTURAL DEVELOPMENT POLICIES, INTERACTIONS IN THE RURAL SECTOR



impact of different policies on the food intake of farmers. Inedible crops are defined as the cash crops plus food crops in excess of on-farm consumption, i.e. marketable surplus. Edible crops are food crops eaten on the farm. Agricultural policies will obviously have a different effect depending on whether they are directed toward food crops or cash crops. Food crops have a direct effect on food intake (through edible crops), whereas cash crops only influence food intake through their indirect effects on income, and by limiting the acreage and labor that is available for food crops. Food policies can result in a decrease in food crops for home consumption and/or an increase in such crops being sold for cash. They can also increase income directly; food stamps in essence augment family income by the difference between their purchase price and exchange value. Nutrition programs either act directly on food intake or on increasing the availability of edible crops, for example through the encouragement of home gardens. Welfare programs (i.e. income supplements) usually have an indirect effect on food through changes in income. If "welfare" programs included such items as low-interest credit to poor farmers then there may be additional indirect effects.

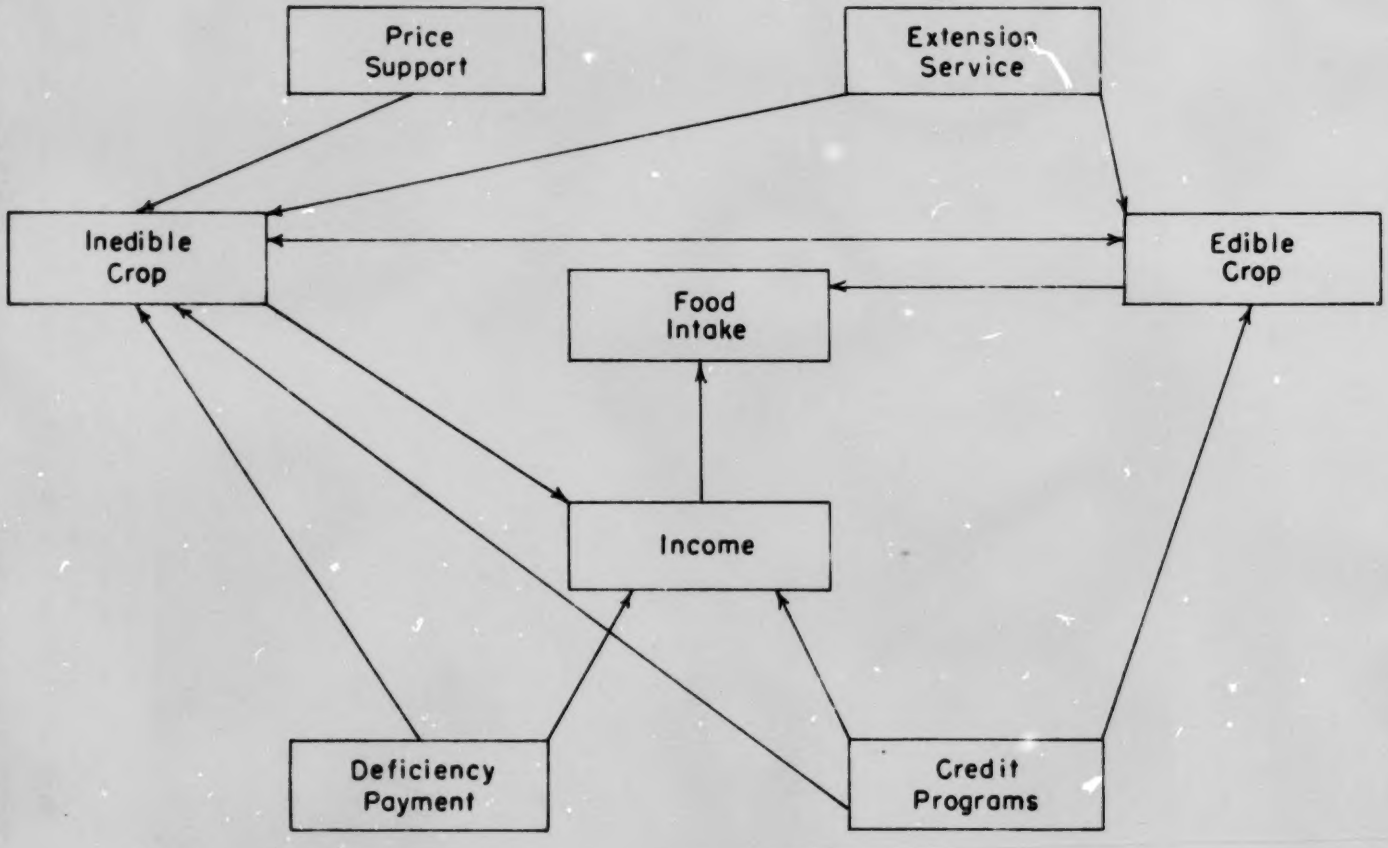
Producer Oriented Policies

In Figure 2.2 the probable influence of four specific agricultural policies (price support, deficiency payment, credit programs, and extension services) on food intake are indicated. For all these policies one of the main determinants of their possible effects is whether they deal mostly with cash or food crops. If a cash crop is grown the main question is how much income can farmers make from it, and this is largely dependent on the demand and supply situation for the crop under consideration. The decision of the amount to grow and the income derived therefrom will depend on the price level in the particular area and the amount of risks as perceived by the farmer in growing that crop. Secondly, the question of how much cash crop to grow will be determined by, and in turn determine, the amount of food crop grown due to labor and land constraints. On the consumption side, an important question is how much of the increment in income will be spent on food? More specifically, will it result in as much food as could have been obtained from home production?

If the crop is an edible crop the item of first importance is will it be so highly priced on the market such that it becomes a cash crop to the subsistence farmer. That is, will they be tempted to sell it and buy more of a cheaper food? If the answer is no, then it is necessary to ask whether the family will eat this crop, i.e. do they like it and do they eat enough of it to make the program or policy worthwhile? A further aspect is what is its nutritional value? There may be a more nutritionally efficient crop that also fits the particular growing conditions and consumer preferences.

Just these few questions about crops highlight the multifaceted nature of the farmer observed as both producer and consumer. Even at this superficial level of discussion it is clear that basic information needed to determine policy effects includes:

FIGURE 2-2. PRODUCER ORIENTED POLICIES AND THE RURAL HOUSEHOLD



i) the supply, demand and price situation for agricultural products;

ii) the usual quality and soil type and amount of acreage available to subsistence farmers;

iii) the income elasticity of demand for food;

iv) local food preferences; and

v) the nutritional content of the food crops.

Price support policies are generally devised for one of two objectives: to increase farm incomes or increase output. Price support policies can point the direction for relative changes in output amongst crops, as well as increase aggregate output. Deficiency payments are income policies from the farmer's point of view, but can be used to increase output. They are devised to ensure a specific return through providing the difference between a desired price and the market price to farmers. Deficiency payments are alternatives to price supports which have as their emphasis the providing of adequate farm income without affecting consumer prices.[1]

Price support policies and deficiency payment schemes are similar in that they both are policies which usually apply to one crop at a time which limits their direct effects to just those crops. The difference between the policies is that deficiency payments have a more visible, direct impact on income than price supports and do not affect market price. A secondary consequence of these policies is the encouragement of the production of certain crops to the possible detriment of others. This and the probable change in income can exert a conflicting influence on food intake.

Credit programs and extension services are not usually as crop specific as price policies because even if they are primarily directed towards one crop they may have ancillary beneficial effects on the whole farm. For instance, an extension program to promote better irrigation of rice will also help in the irrigation of other crops being grown. The same applies to a credit program: if the government is extending credit to promote fertilizer use, this will rarely benefit only one crop. Credit programs and extension services often go hand in hand. If one wants to encourage the use of a new strain of seeds, for example, then it is usually necessary to provide credit to buy those seeds. Credit programs can be utilized to relieve existing debts to local moneylenders, promote the use of new technology, or simply facilitate the more efficient use of existing resources. Extension programs are generally aimed at providing information on new technologies or advice on present farm practices. Both these policies have indirect effects on food intake through their impact on cash and/or edible crop production. Credit programs also have a direct effect on income, in that they free up assets (such as food crops that would otherwise have to be sold) that would have been used

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1 This assumes the economy is open.

to pay the high interest charges of a moneylender. There is a bias in extension in less-developed countries to cash crops which may limit their overflow effects, if the information is too specific.

Consumer Oriented Policies

In Figure 2.3 four specific food policies aimed at increasing food consumption of the poor and their influences on food intake are illustrated. Two of these programs have simple, direct effects on food intake, namely, home garden programs and nutrition education programs. In urban situations these two programs are often found in conjunction under the title of an applied nutrition program. The home garden section concentrates on supplying horticultural information and starting materials. In the rural setting the education part of the program comes to the fore in an attempt to convince people to grow and serve more of certain items. For example, in the Philippines an effort was made to encourage the growing of more green, leafy vegetables to help eradicate vitamin A deficiency.[1] Like most of these efforts (9) it was not very successful because the food habits of the region were not conducive to accepting vegetables. Therein lies the fallacy of most nutrition education programs; i.e. the premise that it is not only desirable but possible to change the food habits of people. Food habits result from two forces:

i) the environment--those foodstuffs that are locally available will be utilized; and

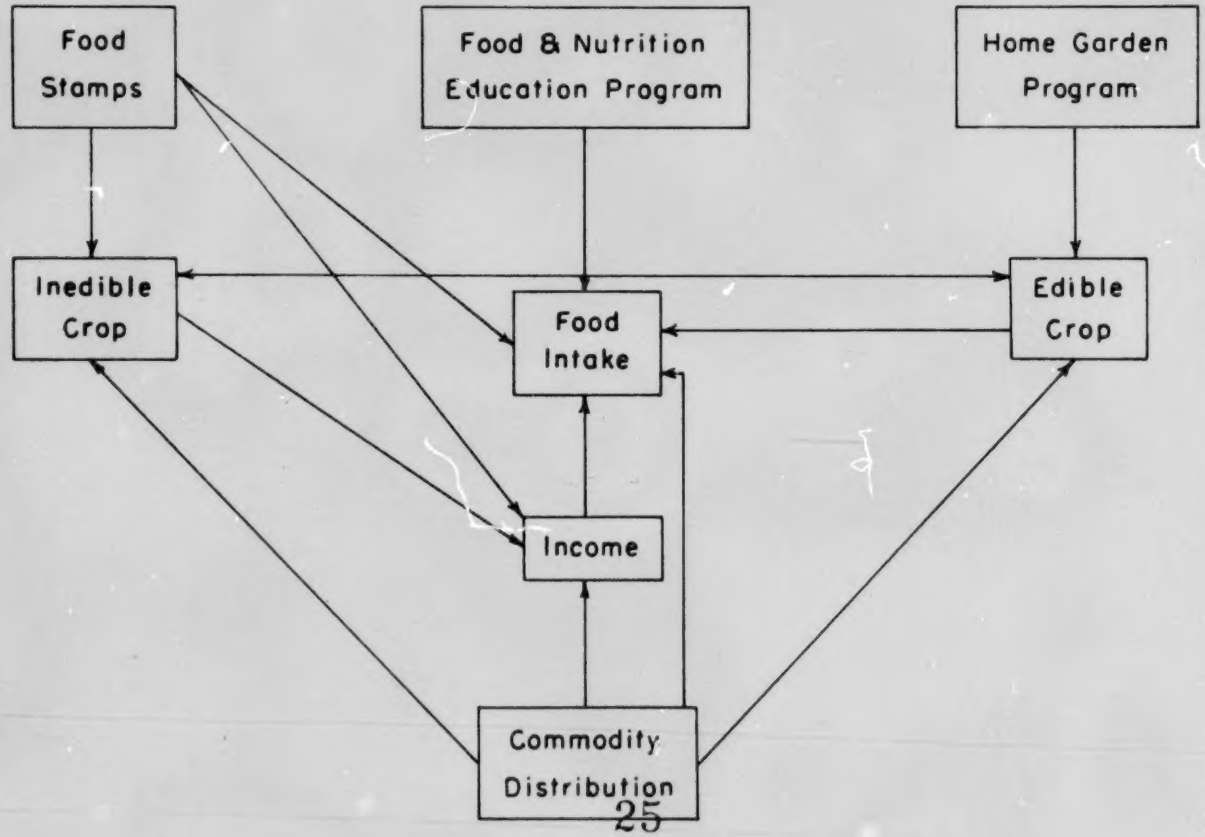
ii) tradition--given a choice people will eat as they have eaten in the past (5:117).

Given these facts it is the difficult task of nutrition educators to try to widen the food horizons and knowledge of those most in need of such. The teacher of nutrition, as any good teacher, must provide a sense of understanding, as well as factual knowledge (48:144). Simply to be told that one must eat fruit to get vitamin C has much less of an impact than to state that vitamin C is necessary to prevent scurvy, is available in many fruits which, for those with weight problems, are also low in calories.

Despite many efforts at nutrition education programs, they have generally been much less effective than hoped and more administratively expensive than planned. The reasons for this are that the small group approach which is utilized is costly and does not reach very many people. Their impact also depends on the charisma and persuasive power of the teacher. Mass communication techniques have as of yet not been successfully employed in a national nutrition education effort. In summary, neither home garden nor nutrition education programs have been very effective in improving the nutrition of large masses of people. They have their place, however, and could play a greater role, particularly if mass communication techniques could be exploited. They can have either a very direct impact on nutrition

1 Latham, Nutritional Sciences 680: International Nutrition Problems, Policy and Programs, Cornell University, Fall 1976.

FIGURE 2.3. CONSUMER ORIENTED POLICIES AND THE RURAL HOUSEHOLD



through influencing the type of food people choose to consume or through the encouragement of the cultivation of food for home consumption.

Food stamps, by comparison, have a much more complicated effect on the food intake of food producing families. Food stamp programs work on the basis of charging families a fee commensurate to their incomes and equivalent to that which they already spend on food.[1] In return, they are given coupons of greater value, but which are redeemable only for food. They must buy in the required proportion of money to stamps and may buy no more than their maximum. The effects of such a program on participants are three-fold:

i) the stamps act as an in-kind income supplement (40), thus affecting the budgeting decision between food and non-food items;

ii) participants experience an increase in purchased food; and

iii) there is likely to be a movement of more food crops into inedible crop status since a larger marketable surplus of staples will be available.

Whether or not a household decides to participate depends on their income level and the required cash payment; their preferences between food and non-food items; and their ability to sell the larger marketable surplus of food or more into other cash crops.

Figure 2.4 illustrates the budgeting situation between purchased food and other expenditures for a subsistence farmer with a given family size and income. Segment AB is the budget line before food stamps. BE represents the purchase requirement or "cost" of the food stamps which allows an increase of FG (or AC) in purchased food. Since the stamps restrict the increased income to food, the new budget line is BFGC instead of DC. The rays 1, 2, and 3 represent the three possible cases of income-consumption curves, dependent on their respective indifference curves between purchased food and other expenditures (37). Ray 1 indicates a household whose preferences are biased away from purchased food, such that they would not take part in a food stamp program. These households would remain on the original budget line and consume at point H because they do not consume as much food as the purchase requirement. The second ray represents households which normally spend more than the purchase price of the stamps, but less than the amount possible with food stamps. They will be forced to G where all discretionary income will be spent on non-food items. Since with the purchase requirement of BE they can move out to G, there would be no point in staying at K. They cannot, however, reach the preferred point I. The income effect is the JK portion of the shift while KG is the in-kind effect of food stamps. The third household type, ray 3, indicates a household which purchases more food than

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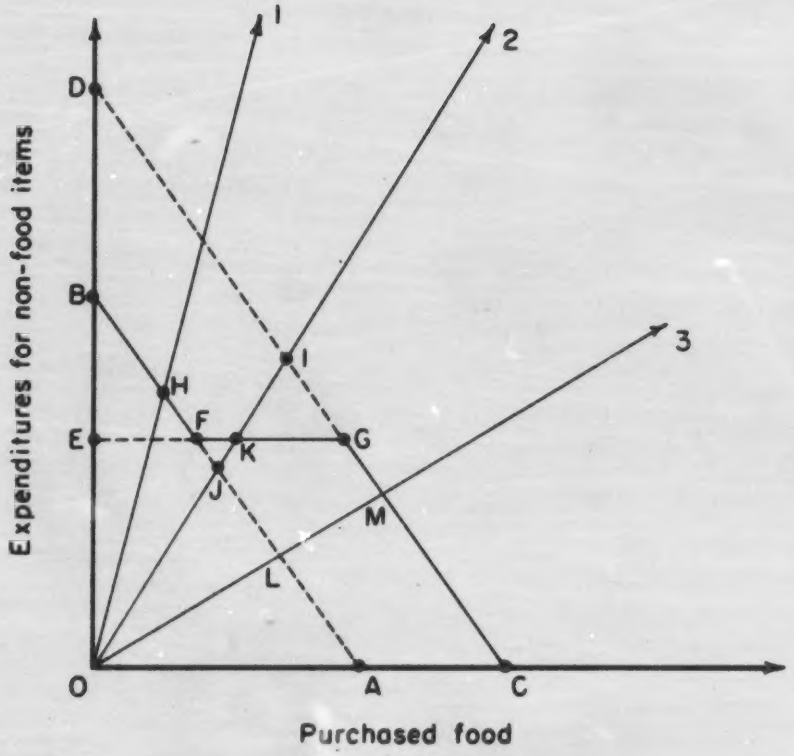
1 The process of deciding on these levels of present expenditure on food and therefore fees, is a problem in and of itself. The ramifications of this decision process will not be covered in this analysis.

FIGURE 2-4. BUDGET FOR PURCHASED FOOD IN THE FARM HOUSEHOLD



the food stamp allotment. These people experience a higher indifference curve at M solely because of the income effects.

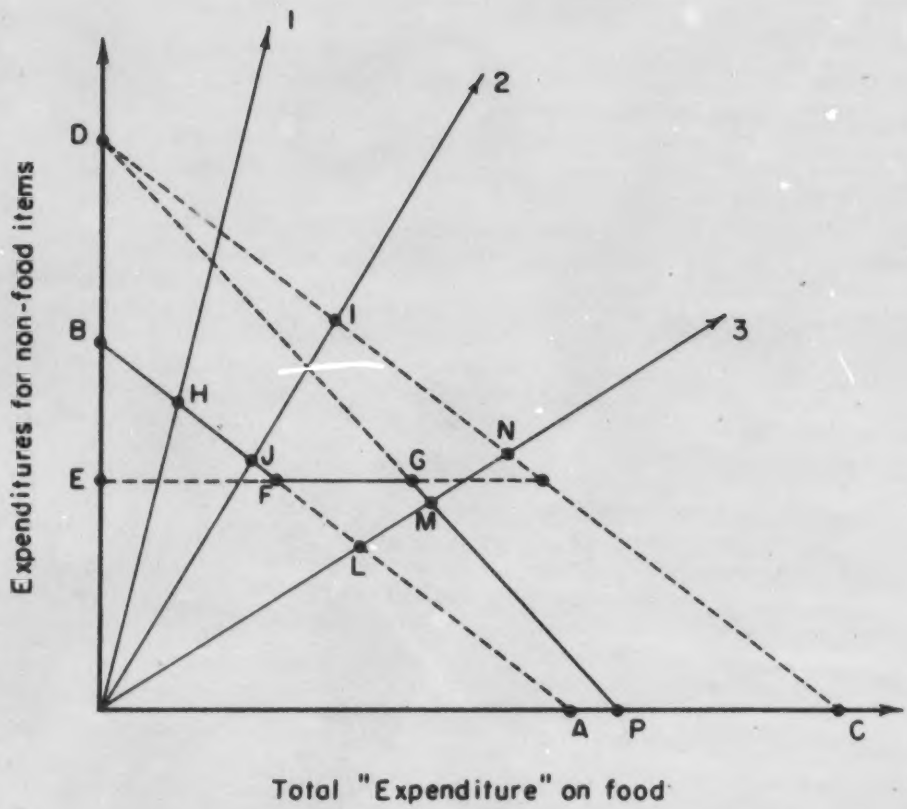
If instead of purchased food, total "expenditures" on food were used (where imputed prices were given to home produced food), the results would be those in Figure 2.5. Points B, D, and E are as in Figure 2.4, that is, the assumed income level and purchase requirement are the same. However, A and C have moved farther out on the food axis to indicate the lower "prices" of home produced food now being included. With food stamps the possible food increase is still FG, however, this is no longer equal to AC as in Figure 2.4. This is due to the fact that the increase in food of AC is possible only with increasing home production, as well as purchases. Since the food stamp program only improves access to purchased food, the new budget line is DP instead of DC, where the steeper slope of DP indicates the higher price of purchased food. The actual kinked budget line is BFGP.

It is of interest to note that of the three rays (which have the same angles as in Figure 2.4) only one of them, ray 3, shows the household participating in the program. It may be inferred from this that, ceteris paribus, it will be difficult to get the program participation rate expected from analysis of purchased food (Figure 2.4) for semi-subsistence farmers. However, comparison of these figures could be misleading in that the typical food-producing household is likely to have a higher preference for non-food items because food is available on the farm. This would cause more households to have income-consumption curves similar to ray 1 in Figure 2.4, whereas in Figure 2.5 with all food more households are likely to be closer to rays 2 or 3. Therefore the indications of greater difficulty in procuring participation in the program in Figure 2.5 can be shown in Figure 2.4 given an assumption that ray 1 is more typical for food-producing households.

In summary, the impact of food stamp programs on rural subsistence farmers depends on many factors, but it is clear that desired participation rates may be harder to achieve than in an urban setting due to the complicating effects of home produced food. Food stamps will have a direct effect on food intake, income, and the amount of marketable surplus. These will lead to secondary effects on crop production. For example, an increase in real income created by food stamps which increases the demand for food could induce an expansion in the production of food for sale.

Commodity distribution programs have typically arisen due to the existence of surplus food commodities which the government has acquired as a result of price support policies or through gifts from foreign countries who are experiencing over-production problems. Since the main thrust for these programs has been from the production side, as opposed to their possible consumption benefits, distribution is often sporadic and poorly administered. Even when they are well administered fluctuating types and amounts of food can often disrupt the program enough to discourage reliance on it by other than the most needy.

FIGURE 2-5. BUDGET FOR "TOTAL FOOD" IN THE FARM HOUSEHOLD



In the rural subsistence sector, a commodity distribution program can have direct effects upon food intake, the amount of home produce consumed, the amount of food sold, and upon income. A program could disrupt the ability of local producers to market their surplus, thus reducing their income. Alternatively, it could give semi-subsistence farmers a larger marketable surplus, if they are participating (as consumers) in the program, which, if marketing channels are available, could provide increased income. For those families who are forced to buy staples, the commodity program would allow more income to be used for non-food or alternative food products.

In essence, the impacts of consumer oriented food policies in the rural sector are many and varied as illustrated in Figure 2.3. This is not to say that it is impossible to come to any conclusions about which policy might be the most effective, rather that the ramifications of each policy must be investigated in depth before implementation. Most importantly, it must not be expected that policies which are effective in the urban sector will necessarily be so in the rural sector. It may be that the "best" policy for the rural sector is not one of those discussed above, but rather a totally new as yet unexplored policy that is applicable solely and explicitly to the rural semi-subsistence sector.

Integrating Nutrition into Planning

The consideration of nutrition earlier in the policy process might clarify and prevent some of the confusing interactions discussed above. One way to do this is to include nutrition explicitly in the planning process. Nutrition has for some time been only incorporated in planning when funds were available for specific nutrition programs, e.g. items such as mothercraft centers where women could get information on health care and nutritional supplements for their children. Development planners have considered nutrition as a "luxury" (11:301) and therefore have considered it as a low priority item. There is a growing awareness that the simplistic approach of increasing aggregate output of food and even income redistribution efforts (11: 247, 8) will not in and of themselves improve the nutritional status of people on the low end of the income scale. The United States is an example of this very fact. How many of our poor still have inadequate diets, despite the over-all improvement in the lowest income level?[1] How many malnourished are there regardless of how much money is put into food stamp programs? Why is this possible in such a "developed" country? One reason may be the lack of regard for the inclusion of nutritional goals and impacts in the planning process, or a choice of inappropriate policies even with these goals.

A systems analysis approach to nutritional planning has been suggested as an alternative to separate nutrition program implementation (11:255). This process has been most elucidated in Joy's flowcharts (24:171-172) which are reproduced in Figures 2.6 through 2.8.

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1 For a description of the malnourishment in the U.S. see (16: 586).

Figure 2.6: Flow-chart of food & nutrition planning process

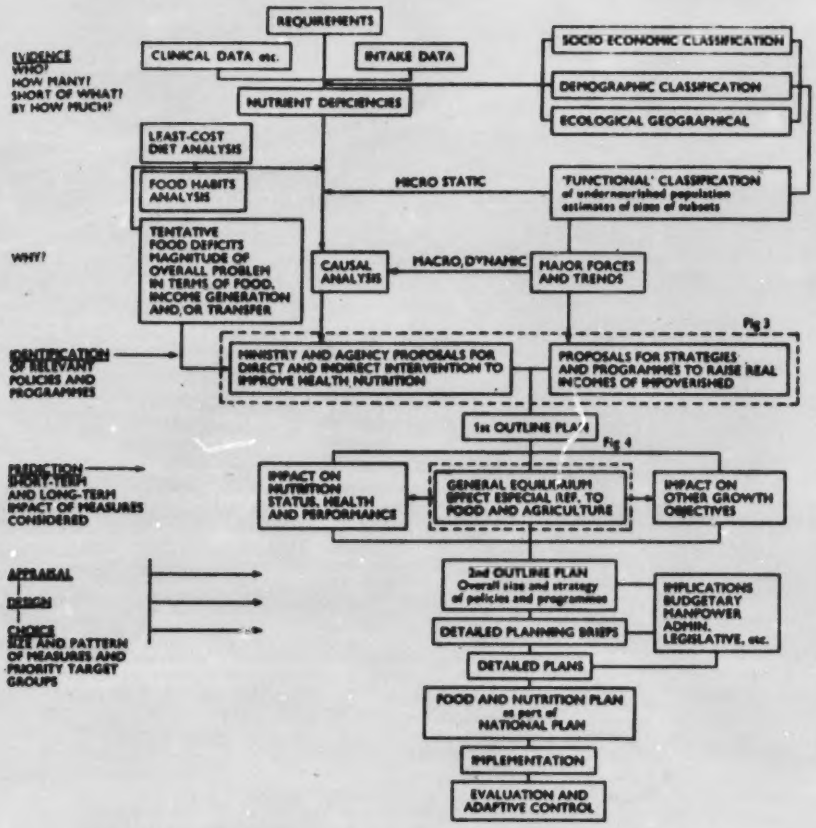


FIGURE 2.7: Elaboration of figure 2.6, "Identification" stage

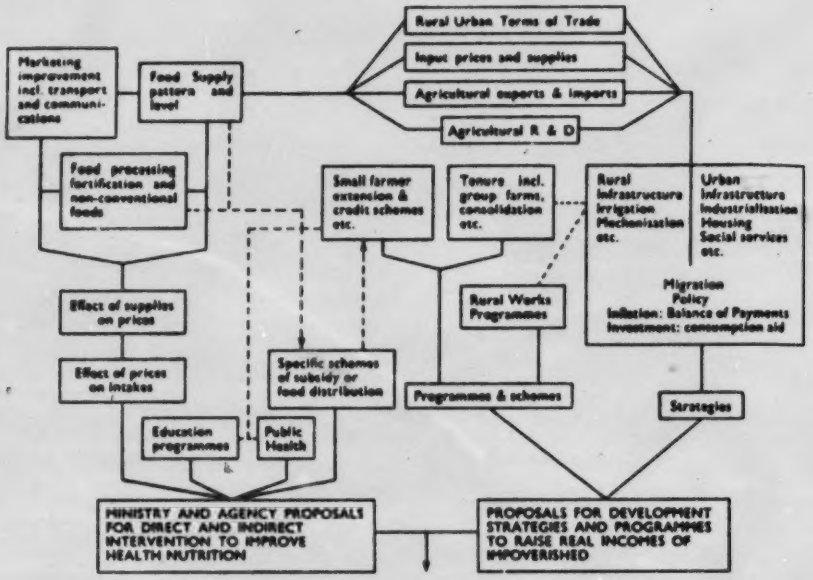
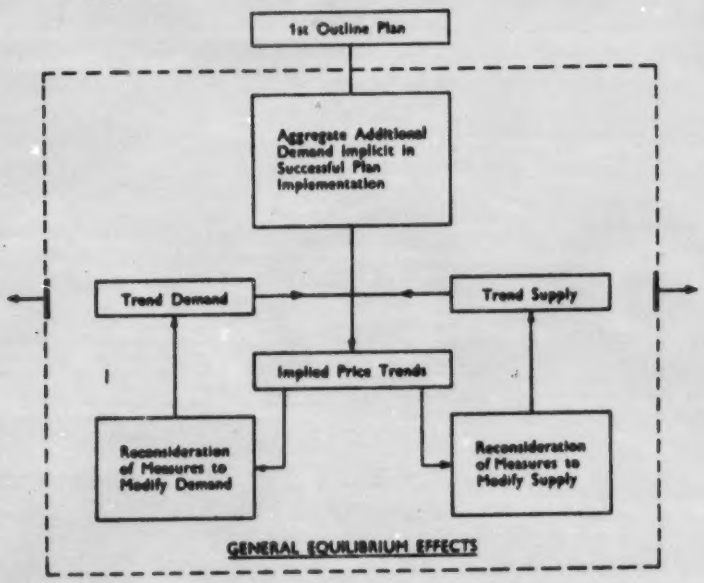

Rural Urban Terms of Trade
Input prices and supplies
Agricultural exports & imports
Agricultural R & D
Marketing improvement incl. transport and communications
Food Supply pattern and level
Food processing fortification and non-conventional foods
Small farmer extension & credit schemes etc.
Tenure incl. group farms, consolidation etc.
Rural Infrastructure Irrigation Mechanisation etc.
Urban Infrastructure Industrialisation Housing Social services etc.
Migration Policy
Inflation: Balance of Payments
Investment: consumption aid
Effect of supplies on prices
Rural Works Programmes
Effect of prices on intakes
Specific schemes of subsidy or food distribution
Programmes & schemes
Strategies
Education programmes
Public Health
MINISTRY AND AGENCY PROPOSALS FOR DIRECT AND INDIRECT INTERVENTION TO IMPROVE HEALTH NUTRITION
PROPOSALS FOR DEVELOPMENT STRATEGIES AND PROGRAMMES TO RAISE REAL INCOMES OF IMPOVERISHED

FIGURE 2.8: Elaboration of figure 2.6, general equilibrium box


1st Outline Plan
Aggregate Additional Demand Implicit in Successful Plan Implementation
Trend Demand
Trend Supply
Implied Price Trends
Reconsideration of Measures to Modify Demand
Reconsideration of Measures to Modify Supply
GENERAL EQUILIBRIUM EFFECTS

The first step in including nutritional goals in the planning process is to identify the "who" and "why" of nutritional problems within the country. Aggregate knowledge of nutritional status, such as offered in Table 1.1 is of little use to planners. More specific information of at least a regional, age-sex, income class, and type of deficiency nature is needed. This is not to say that a quantification down to how many grams of each nutrient is consumed is necessary. Some methods for exploring the nutritional status of a population are through data possibly already available: consumer expenditure surveys, food consumption surveys, and medical nutrition surveys. Generally, the data from the first two of these will have to be paired with other data on income distribution and the nutrient content of local foods in order to get directly useful nutritional information (11:251). Alternatively, a second-source survey can be done instead of, or in conjunction with, the above. Second-source surveys are:

> ...based on (1) collective impressions from interviews with nutrition experts as well as with an appropriate sampling of local public health officials and others on the local scene likely to have insights from constant exposure to the problem; and (2) a compilation and analysis of all relevant earlier studies--including village work of cultural anthropologists and medical surveys conducted for other purposes--which, when patched together, may begin to present the outlines of a distinctive pattern.[1]

At the same time as analyzing who is nutritionally deficient, an attempt should be made to determine why they are deficient. The latter is necessary to use the survey information effectively in the planning process.

The second stage of analysis is the identification of relevant policies and programs. Malnutrition need not be associated with rural subsistence communities, rather it is associated with poverty and change (53:176). There are two relevant types of policies whose potential effects must be analyzed:

i) development strategies in general (indirect effects), and

ii) nutrition programs <u>per se</u> (direct and indirect effects).

Figure 2.7 is an elaboration of this stage, illustrating the complicated interactions of policies and programs. This identification stage and the third or prediction stage are where economists can be of most help.

It is necessary for the planner to know not only what programs are likely to effect nutrition, but whose nutrition, how, and by what amount. Due to the two types of policies involved, the analysis of programs will take two forms. First, there should be an analysis of

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1 Alan Berg, et al., <u>Nutrition, National Development and Planning</u>, (Cambridge, Massachusetts: MIT Press, 1973), p. 252.

the probable benefits of nutrition and health programs aimed at specific problems, such as vitamin A deficiency. These should be examined for:

i) whether they aim at the basic cause of the deficiency;

ii) whether they will reach the groups most in need;

iii) whether the deficiency is large enough to warrant a fully fledged program; and

iv) if the program can be integrated with existing programs.

Secondly, any analysis of general development programs will have to be relatively complicated in order to detect indirect impacts on nutrition. Discussion of these policies will take the form of a simultaneous duality. That is, a division into nutrition impacts and impacts on other growth objectives is necessary, but cognizance of their simultaneous effects on the general equilibrium in food and agriculture (see Figure 2.8) must be maintained. A secondary division at this point might be required between the problems of, and policies affecting urban versus rural groups. However, at the basis of all analysis must be the realization that nutrition is largely an income distribution problem (24:182), and since increased incomes are generally a development objective, nutrition will inevitably be influenced by development strategies.

In the appraisal, design, and choice of a national food and nutrition plan within an overall national development plan, cost factors must inevitably be considered. However, a strict benefit-cost analysis may not be directly applicable when a non-monetary "good" such as a well-nourished populace is under discussion. A more qualitative analysis of whether the program will reach the target group more effectively than other available alternatives might be more appropriate. In fact, the prevention of development policies which would have adverse effects on the nutrition of large portions of the at risk population is likely to be of more significance. An example of this would be the prevention of expansion in inedible crops at the expense of edible crops when no other source of the latter is to be encouraged. Detrimental policies could be avoided through the identification and prediction process. The principal question at the point of appraisal will be what program can achieve similar development objectives, using the monies available, and not have a detrimental impact on nutrition (if not a beneficial one)?

In summary, it is clear the inclusion of good nutrition as a goal in development planning will be complicated. However, the rewards from avoiding detrimental programs are likely to be many. It may be simpler in the long run to include nutritional goals directly in the planning process in order to avoid expensive nutrition programs to act as "patches" after the plan is complete. Secondly, discerning the probable effects on nutritional goals of a group of policies once they have been devised is likely to be more difficult than the inclusion

of nutritional objectives throughout the planning process. The next chapter will discuss some methods of describing the nutritional status of groups of people and discerning what variables effect it. One of these can be the first step in discerning a policy's impact on nutrition.

CHAPTER 3

SUGGESTED METHODOLOGIES TO DETERMINE THE NUTRITIONAL IMPACT OF POLICIES

The policy-making process can benefit from economic models in two ways:

i) through an evaluation of the impact of a proposed policy on key variables, or

ii) the economic situation itself can be examined to discern the policy instruments likely to "best" meet specific goals.

An example of the first usage would be the case where a price support policy was proposed, but it was necessary to evaluate its probable nutritional effects before adoption. The second situation could be where a government wishes to improve the nutritional status of a sector of the population, but needs information on whether to do so through income-related or food stamp policies. Four types of methodology are discussed below: input-output models, nutritional deficiency indexes, food consumption approaches, and nutrient consumption approaches. Of these methods, only the food consumption approach allows prediction of the impact of policies. The deficiency index approach can also be of some help. The nutrient consumption approach is strictly a descriptive device to provide a basis for weighing the probable effects of different policy instruments.

Nutritional Objectives and the Allocation of Resources

Input-output (I-O) models have been used in attempting to optimize resource use in agriculture, subject to nutritional and foreign exchange constraints. As a basis for planning these can be useful. However, there are many difficulties to be overcome in deriving an I-O model that will give realistic results. The general unreliability of available data is a serious problem. Also, the costs of this type of analysis are generally prohibitive for a developing country and not justifiable in comparison to alternative uses of financial resources. A short discussion of two attempts at such analyses will illustrate their fallibility, as well as applicability.

Smith (50, 51, 52) has done an exhaustive study on Nigeria using an extension of least-cost diet analysis.[1] His approach

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1 For an example and explanation of least-cost diet analysis see Stigler's (54) classic article.

involves the maximization of non-food income subject to the constraint that specified nutrient levels be attained. Food (defined as food consumed within Nigeria) was valued in terms of the cost of nutrients whereas non-food items (defined in terms of other agricultural income) were valued at market prices. Market prices were not used for food because it was felt that the opportunity costs of food to subsistence farmers and the country as a whole are the costs of producing the required nutrients. These costs were derived in terms of the opportunities foregone in producing for non-food income (e.g. for export) (50:145).

His methodology as applied to Nigeria identifies four critical nutrients: calories, riboflavin, calcium and vitamin A. These are costly since it is necessary to forego income-generating non-food production, to provide these in adequate amounts. The crops capable of meeting adequacy at the lowest cost for each area of the country were determined. The six most useful were sweet potato, yam, cassava, cocoyam, soya bean, and maize (50:149). In summary, he finds a potential for increasing non-food income by 36% of the 1967 Gross Domestic Product (52:36) while providing adequate nutrition, through changes in the types, regional distribution, and amounts of crop production.

There are many potential criticisms of this methodology, not the least of which is its failure to include price and income effects on the low-income consumers. Distribution problems cannot be assumed away on the basis that aggregate non-food income will increase, therefore, the poor will have money to buy food. Secondly, it is a static analysis that fails to describe possible effects of changes in policies, i.e. it is simply an optimization of the present situation with very little idea of whether it can be realized. (He does, however, vary the technology through the input coefficients to show effects of changes from traditional to modern technology.)

His results can also be criticized for their lack of correspondence to current nutritional reality in Nigeria. The main nutritional syndromes are PCM and anemias (22:51). There is no evidence of the existence of a calcium deficiency. Riboflavin deficiency was found to exist on the unreliable basis of angular lesions and scars,[1] and if indeed it does exist is a minor health problem (22:51). Considering the high usage of red palm oil, vitamin A deficiency is unlikely. Thus, the inclusion of calcium, riboflavin and vitamin A as critical nutrients is unfortunate.

Sweet potato, yam, sweet cassava, and cocoyam are four of the six crops used to meet the low-cost nutrient needs. Of these four none contain more than 1.9% protein by weight and all contain more than 61% water (22:51). The physical bulk of these foods limits the amount children can eat, thus heavy reliance upon them increases the chances of malnutrition, particularly kwashiorkor, in infants and toddlers.

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1 These are evidences of <u>possible</u> riboflavin deficiency, but they can be from many sources.

A second linear programming approach has been formulated by Norse (42). This method can be used to determine the optimum, least-cost development strategies for increasing food production and has been tested on a few Asian countries. The results show the primary limitations to nutritional improvement to be institutional, e.g. pricing policy, lack of effective demand, and credit availability. Again this model cannot predict effects on people of different income strata. It is simply an optimization of the current situation by varying production inputs. However, the results seem to be consistent with the fact that institutional, rather than supply constraints are more significant in the determination of nutrition.

These linear programming approaches, as presently formulated, can do little to provide input into the planning process. Perhaps they can be improved to provide a basis for predicting policy effects, since more specific, policy-oriented techniques are needed.

Nutritional Deficiency Indexes

Economists and planners have tried to devise a single summary indicator of nutritional status. It is clear that it would be much simpler to discuss the nutrition of a group of people if one did not have to be concerned with so many nutrients. However, for the most part over-consumption of one nutrient does not make up for under-consumption of another. Therefore, any process involving averaging of nutrient "achievements" is inherently invalid. Despite this objection, an all-encompassing measure is still sought. It is worth describing some of these indices and pointing out the better ones.

The first of these measures was the Mean Adequacy Ratio (MAR) which was developed and used by Madden and Yoder (34). The MAR is defined as the simple unweighted mean of ten Nutrient Adequacy Ratios, where each nutrient adequacy ratio is the 24-hour intake of a nutrient divided by the appropriate RDA (determined per household by the age-sex distribution of, and number of meals eaten at home by the household members). Regression analysis was used with the MAR as the dependent variable, to observe how food stamps, commodity distribution programs, and socioeconomic variables relate to nutrient adequacy. On this basis, the food stamp program was found to be insignificant in its effect on MAR.

The second measure is not an overall one, but attempts to relate nutrient intake to a dietary standard. This is the Nutrient Achievement Ratio (NAR)[1] and is computed for each nutrient under consideration. The NAR is nutrient consumption per day divided by RDA. This measure is more justifiable than the MAR, in that it does not attempt to group nutrients together. Yet, it still standardizes nutrient consumption to the RDAs.[2]

1 The NAR was developed by S. Lane, "Food Distribution and Food Stamp Effects on Nutritional Achievement of Low Income Households in Kern County, California" (Unpublished), cited in P. Neenan (42:20).

2 In chapter 5 the pros and cons of "letting the data find their own RDAs" is discussed.

Given the controversy about what the RDAs should be, it seems tenuous to introduce them directly into a regression analysis. Also, there is the question of whether the homemaker's nutritional status is truly an indicator of the welfare of the family. One of the major nutritional problems is the distribution of food within the family and it is therefore doubtful whether one member, particularly an adult, can adequately represent the nutritional status of the family. The principal individuals "at risk" in a family are children, and this could be overlooked on the basis of the homemaker's nutrition.

Another aggregate measure of nutritional status has been developed theoretically by Tyrrell (62:6), but not implemented in any study to date. His multinomial logit budget allocation model allows the derivation of how much of each type of food is consumed by each type of person in the household. Converting this food consumption by individual to nutrient consumption, one arrives at $\hat{n}_{rs}$: the estimated consumption of nutrient r by person of type s. If $\bar{n}_{rs}$ is the standard or RDA, then

$$(3.1) \quad \hat{D}_s = \sum_r \Phi_{rs} \text{ Max } (0, \bar{n}_{rs} - \hat{n}_{rs})$$

is a measure of nutritional deficiency.[1] There are problems in this, the major one being the choice of Φ_{rs} which is a weighting factor for the r^{th} nutrient for the s^{th} person. Deciding whether to weight vitamin A over protein or vice versa for a one-year-old child, is not something that is easily resolved. However, this is a promising measure, in that it does deal with categories or types of individuals within the household rather than relying on one person's nutrition to describe the household. It also allows considerable flexibility in terms of the choice of weights by type of person. Perhaps it would be best to simply average the $\hat{n}_{rs}$ over households by income groups to get an idea of the intake levels of each nutrient by type of person, rather than averaging over nutrients per individual.

In summary, nutritional deficiency indexes are not as valid as some assume they are. To obliterate a severe iron deficiency by averaging it with a high consumption of calcium is to do away with any knowledge that has been gleaned from your data. However, it cannot be denied that it would be so much simpler if weighting factors could be developed which would allow the discussion of a person's overall nutrition in place of a half dozen nutrients. It must be noted that even if there was a perfect overall indicator of nutrition, when it came to trying to eradicate deficiencies it would still be necessary to specify information on a nutrient by nutrient basis.

Food Consumption Theory Approaches

One of the basic approaches to determining nutritional status is through analysis of food consumption using conversion factors for nutrients by type of food. Household consumption surveys generally

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1 Note that the Max (0,) operator simply allows only nutrients that the individual is deficient in to be considered.

provide the data from which a demand or consumption analysis can be derived. Two methodologies have been used in analyzing food consumption. The first is through developing a complete price elasticity of demand matrix for food (45). The second is through a budget allocation model (62).

The demand elasticity method has been suggested by Pinstrup-Andersen, et al. (45) and applied to data on Colombia. There are three phases to this methodology:

i) the estimation of a price elasticity of demand matrix for food by income levels as well as for the whole market;

ii) determination of the effect of an increase in supply[1] of one commodity upon the consumption of all foods by income group;

iii) conversion of the "final" food consumption to nutrient consumption.

Pinstrup-Andersen, et al. (45) identify three issues in using an expansion of supply as a method to improve nutrition. Firstly, whether the cost of expanding supply of a commodity to increase the availability of a nutrient is worthwhile. That is, how much of the additional food is eaten by the target population (direct impact), and whether this could be achieved more efficiently by a different policy. Secondly, what is the indirect impact on nutrition due to effects on the consumption of other food goods. Thirdly, what is the resulting "net" impact on nutrient consumption of the target group, i.e. whether it is positive as hoped.

Estimation of the price elasticity matrix is based on neo-classical demand theory. Specifically, Frisch's (21) method of obtaining a complete set of own and cross price elasticities from knowledge of the income elasticities (estimated from cross-section data), budget proportions, and the flexibility of money is utilized. This is possible only through the assumption of want independence between commodities[2] implying direct additivity of the utility function.

The second phase of the model determines the changes in consumption given a shift in supply of one of the food commodities. One market is assumed to exist for all consumers wherein perfect competition prevails and is in equilibrium before the shift in supply. A set of recursive equations is estimated in an iterative manner so as to arrive at a final "new" equilibrium price and quantity for each commodity. The final prices and quantities are then used to provide estimates of each commodity consumed by income level.

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1 Pinstrup-Andersen has applied this analysis to income policies as well (44), but that will not be discussed here.

2 Want independence means the marginal utility of one commodity is independent of the amount consumed of any other commodity. This does not imply demand independence.

The estimates of food by income level are then converted to calories and protein to determine the direct and indirect impacts of the change in supply on the nutrition of the target income strata. From these data three indicators of nutritional impact are developed:

i) percentage change in total supply increase consumed by nutritionally deficient income groups;

ii) change in per capita calorie and protein intake for deficient groups;

iii) percentage decrease in total calorie and protein deficiencies.

On the basis of these indicators, commodities are ranked as to their desirable priority for either calorie or protein nutrition goals. Pinstrup-Andersen determined priority commodities by utilizing three different cost assumptions and two elasticity of supply assumptions. Hence, there was a possibility of using up to six different commodities for meeting each of the two (sufficient protein and calories) nutritional goals. In the application of this model to Cali, Colombia, the priority commodities for calories tended to be rice, oilseed, cassava, and potatoes; whereas the priority commodities for protein are beef, beans, and maize.

Two other general conclusions were also made by Pinstrup-Andersen (44). The increase in the total nutrient supply is not a good indicator of improvement in intake by target groups. This is because the percentage received by these groups of an increase in total supply of a good can be quite low (e.g. 12% of milk for calorie deficient strata and 22% of peas for protein deficient strata[1]). Secondly, little can be done about nutritional problems through supply expansion. This was shown through the fact that even with increases in supply of 10% the reduction in calorie and protein deficiencies was very small (calorie and protein deficiencies could be reduced by around 6% each depending on the food chosen and the elasticity of supply[2]).

This methodology appears to offer many possibilities for flexible determination of the nutritional impact of agricultural policies. However, there are limitations to the possible scope of the analysis as well as in the specific application of it to Colombia. Urban consumers are well described in this model, yet the effects of supply changes on the rural subsistence farmer cannot be shown. Also, the analysis does not address the question of intra-family distribution of nutrients; in fact, the analysis goes down only to the per capita intake by income level. Additionally, the model cannot state anything about what the probable percentage utilization of any increase in nutrients may be. Not all of an increment in food consumption may be utilized by those consuming it due to ancilliary problems,

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1 From table 5 of (45).

2 From table 8 and text page 140 of (45).

such as disease or parasites. In this analysis of the Colombian situation many approximations had to be made due to a lack of time series data. A rough estimate of the flexibility of money was made; the elasticities of supply could not be estimated, and had to be "set" at various levels; plus the Frisch method of finding price elasticities is not strictly valid on such commodities as types of food, due to the assumption of want independence. Despite all of these limitations, the analysis represents a pioneering attempt to provide information about the impact of alternative policies on nutrition.

The second method of analyzing food consumption data is analysis of family budget data, which can provide estimates of individual demand (within the household) for all goods including food. The model has been theoretically developed in reference to nutritional status by Tyrrell (62). The analysis derives a function, f_{is}, to estimate the personal budget share, w_{is}, of the i^{th} good for the s^{th} type of person namely when

$$(3.2) \quad f_{is} = \sum_{k=1}^{N} \beta_{ik} \ln(P_k) + \gamma_i \ln(M) + \sum_{t=1}^{S} \delta_{it} \frac{FM_t}{FS} + \alpha_s$$

where P_k = price of the k^{th} good, k=1,2,...,N

M = family income

FM_t = family members of type t, t=1,2,...,S

FS = family size

α = effect of the s^{th} family member on their own budget (differing by s, but not k);

then

$$(3.3) \quad w_{is} = \frac{FM_s \, e^{f_{is}}}{\sum_j \sum_t FM_t \, e^{f_{jt}}} \qquad \begin{matrix} i = 1,2,...,N \\ s = 1,2,...,S \end{matrix}$$

The first two terms in 3.2 imply that prices and income affect the personal budget share the same as they affect the family budget share of good i. The third term expresses the general impact of family composition on f_{is}. The family budget share for good i, w_i, is from 3.3:

$$(3.4) \quad w_i = \sum_s w_{is} = \frac{e^{\sum_k f_{is}}}{\sum_j e^{\sum_k f_{js}}} \qquad i = 1,2,...,N$$

The personal budget share for all goods is

$$(3.5) \quad w_s = \sum_i w_{is} = \frac{FM_s \, e^{\alpha s}}{\sum_t FM_t \, e^{\alpha t}} \qquad s = 1,2,...,S$$

Estimation of the model consists of two parts analogous to equations 3.4 and 3.5 above by the use of logarithms. These equations require family budget data including expenditures, prices, income and household

composition, plus knowledge of a typical set of expenditures for individual household members or a unit equivalent scale. From the estimated model and the knowledge that $\sum_i \sum_s w_{is} = \sum_i w_i = \sum_s w_s = 1$, it is possible to derive the personal budget shares, $\hat{w}_{is}$, as well as personal demand defined as

$$(3.6) \quad \hat{Q}_{is} = \frac{M}{P_i} (\hat{w}_{is})$$

To obtain information on the nutritional status of the s^{th} type of person, the $\hat{w}_{is}$ for those i which are foods, must be transformed via conversion factors, to $\hat{n}_{rs}$: the intake of nutrient r by the s^{th} type of person. This analysis enables one to obtain the nutrient demand by type of individual. Since

$$(3.7) \quad \hat{n}_{rs} = \sum_{i=1}^{n} v_{ir} \hat{Q}_{is}$$

where v_{ir} is the conversion factor for the i^{th} good into the r^{th} nutrient, then by 3.6

$$(3.8) \quad \hat{n}_{rs} = \sum_{i=1}^{n} v_{ir} \left[(M/P_i) \hat{w}_{is}\right] .$$

Therefore, the nutritional effects of policies could be predicted if an estimate of the policies' impact on prices, P_i, and income, M, could be obtained.

Nutrient Consumption Approaches

Recently, direct analysis of nutrient consumption by household has been explored. Data from household consumption surveys on food have been converted to nutrients and summed over the household. Regression analysis with the total of a particular nutrient per household as the dependent variable and income plus other socioeconomic variables has been performed in two studies (1,15). The rationale for these studies has been of two forms:

i) observation of the impact of socioeconomic factors on consumption of nutrients as in Adrian and Daniel (1);

ii) a household production theory approach[1] which allows the discussion of nutrient demand, as in Chernichovsky (15).

Adrian and Daniel (1) utilized data on 6,950 households out of the 7,500 in the 1965-66 household consumption survey. The survey was conducted in all regions of the continental United States with observations organized on a regional and urbanization basis.

In Adrian and Daniel's view the total quantity of each nutrient available per week per household is a function of certain economic

1 This approach to nutrient demand is discussed in chapter 4 of the author's M.S. thesis, "Nutrition in Policy and Planning: The Rural Sector", Cornell University, 1979.

and sociological characteristics. They assume that consumption of each nutrient is affected by the same variables since nutrients are elements of one whole--food. This allows the simplicity of using one model. Secondly, they assume that in the allocation of their income to different foods, consumers are reflecting their desire for an adequate, well-balanced diet. There are exceptions to this, but for the most part consumers must achieve minimal consumption of all nutrients. Since nutrient consumption is limited by the physical capacity of the household members for food, the consumption to income ratio is not expected to be constant for all income levels. Therefore, a curvilinear relation was hypothesized and a quadratic form was determined to be the "best" on the basis of R^2 and the statistical significance of income coefficients.

The final model estimated was

$$(3.9)\quad Q_i = a + b_1Y + b_2Y^2 + b_3U_1 + b_4U_2 + b_5R_1 + b_6R_2 + b_7E_1 + b_8E_2 + b_9E_3 + b_{10}L_1 + b_{11}L_2 + b_{12}L_3 + b_{13}L_4 + b_{14}L_5 + b_{15}S + b_{16}M + b_{17}F + u_1$$

where the variables are defined as in table 3.1. The "zero" category of each of the race, education and life cycle variables was omitted to prevent singularity. The region of the United States was not taken into account because separate regressions on the four regions varied little from the aggregate model.

Except for vitamins A and C, the regressions result in an R^2 of more than 50%. Income and income squared were both significant (see table 3.2) for all but calcium and thiamine. Since income coefficients were positive and income squared coefficients negative, an increase, peak, then decrease in consumption is indicated when income increases. This would be consistent with their assumptions. The income elasticities (table 3.3) they derive for the nutrients are rather low, indicating little response of nutrients to income changes. All of the elasticities are positive except at the $20,000 level (the highest group) for protein, iron and thiamine. In general, the elasticities increase until the middle income range, then decrease for all the nutrients. This form results from the quadratic function chosen for income, i.e. the income elasticity for each nutrient, E_i, is

$$(3.10)\quad E_i = b_1 \frac{Y}{Q} + 2b_2 \frac{Y^2}{Q} \qquad \text{where } b_2 \text{ is less than 0.}$$

Urbanization, which they consider as a proxy for several effects ranging from home produce available in rural areas to the influence of advertising effects, was a significant variable (see table 3.2) except for vitamins A and C. Urban and rural nonfarm groups are affected negatively by their urbanization status, i.e., farm people

TABLE 3.1: Adrian & Daniel's Variables

Q_i	Quantity of the i^{th} nutrient consumed/household/week
Q_1	grams of protein
Q_2	grams of carbohydrate
Q_3	grams of fat
Q_4	tens of international units of vitamin A
Q_5	milligrams of calcium
Q_6	milligrams of iron
Q_7	milligrams of thiamine
Q_8	milligrams of vitamin C
Y	Annual household disposable income in thousands of dollars (utilized midpoints of income class groupings except for $25,000 and above group where $25,000 was used)
U	Urbanization
U_0	rural farm
U_1	urban
U_2	rural non-farm
R	Race
R_0	black
R_1	white
R_2	other
E	Education of the homemaker
E_0	high school
E_1	grade school
E_2	some college
E_3	college graduate
L	Stage of household in the family life cycle
L_0	stage 3: average age of children 6-12 years
L_1	stage 1: no children & housewife $\leq$40 years
L_2	stage 2: average age of children $<$ 6 years
L_3	stage 4: average age of children 12-17 years
L_4	stage 5: average age of children $>$17 years
L_5	stage 6: no children & housewife $>$40 years
S	Family size defined as total members of a household who depend upon a common income
M	Meal adjustment to take care of home versus guest, skipped, & away meals [M = TM - (S) (21), where TM is total meals served and 21 is the total possible meals eaten by one person per week]
F	employment status of the homemaker (1 for employed, 0 for unemployed)
u_i	Error term for the i^{th} nutrient equation

SOURCE: J. Adrian and R. Daniel, "Impact of Socioeconomic Factors on Consumption of Selected Food Nutrients in the U.S.", AJAE 58 (1976) pp. 32-33.

TABLE 3.2: Adrian & Daniel's Results

	Coefficient (Standard Error)					
	Protein	Vitamin A	Calcium	Iron	Thiamine	Vitamin C
Y	80	7014	285	7.09	0.35	160
	(7.8)	(1228)	(100)	(1.63)	(0.13)	(13)
Y^2	-2.32	-132	-6.81	-0.19	-0.01	-3.67
	(0.36)	(56)	(4.55)	(0.07)	(0.01)	(0.57)
U_1	-326	1967	-4637	-82.0	-7.18	20.6
	(33)	(4313)	(350)	(5.7)	(0.46)	(44.1)
U_2	-262	-13886	-2816	-59.3	-5.03	-6.43
	(33)	(5149)	(418)	(6.8)	(0.55)	(52.7)
R_1	154	-22962	4290	-1.21	-1.42	107
	(36)	(5646)	(458)	(7.48)	(0.61)	(58)
R_2	178	1963	3377	36.8	0.89	441
	(81)	(12751)	(1034)	(16.9)	(1.37)	(331)
E_1	-39	-5156	256	5.09	1.30	-164
	(27)	(4230)	(343)	(5.60)	(0.46)	(43)
E_2	11	3083	779	-0.18	-0.29	192
	(36)	(575)	(467)	(7.62)	(0.62)	(59)
E_3	-77	-1344	955	-19.3	-0.89	105
	(45)	(7088)	(575)	(9.4)	(0.76)	(73)
L_1	-255	-31373	-4422	-8.58	-0.67	-438
	(64)	(10077)	(817)	(13.34)	(1.08)	(10.3)
L_2	-240	-15648	-1422	-33.0	-2.51	-274
	(36)	(5616)	(456)	(7.4)	(0.60)	(58)
L_3	208	-2453	1361	35.5	3.30	211
	(40)	(6278)	(509)	(8.3)	(0.68)	(64)
L_4	58	-1485	-1912	13.0	0.64	72.9
	(65)	(10258)	(832)	(13.6)	(7.10)	(105)
L_5	-273	-16283	-4362	-24.0	-2.57	-231
	(44)	(7035)	(571)	(9.3)	(0.76)	(72)
S	520	26523	5585	109	9.59	340
	(8.2)	(1291)	(105)	(2)	(0.14)	(13)
M	32	1777	289	5.99	0.48	27.6
	(0.7)	(117)	(10)	(0.16)	(0.01)	(1.2)
F	25	-2936	417	6.78	0.64	-7.60
	(24)	(3859)	(313)	(5.11)	(0.42)	(39.5)
a	689	84031	7992	141	11.51	540
R^2	0.64	0.18	0.56	0.61	0.65	0.30

SOURCE: J. Adrian and R. Daniel, "Impact...", AJAE 58 (1976) pp. 35-36, tables 1 and 2.

TABLE 3.3: Nutrient Income Elasticities[a]

Nutrient	Selected Income Levels					
	$2,000	$4,000	$8,000	$12,000	$16,000	$20,000
Protein	0.059	0.098	0.126	0.103	0.034	-0.084
Fat	0.066	0.109	0.142	0.119	0.049	0.072
Vitamin A	0.067	0.115	0.172	0.188	0.173	0.130
Calcium	0.019	0.034	0.050	0.051	0.037	0.009
Iron	0.027	0.046	0.065	0.059	0.031	-0.020
Thiamine	0.016	0.028	0.038	0.032	0.012	-0.024
Vitamin C	0.148	0.233	0.299	0.283	0.208	0.078

SOURCE: J. Adrian and R. Daniel, "Impact of Socioeconomic Factors on Consumption of Selected Food Nutrients in the U.S.", AJAE 58 (1976) p. 36, table 3.

[a]These elasticities were derived where all variables were held at their means except income and quantity (which varies with income).

are better off in all the nutrients for which urbanization is significant. The race variable had two dummies, one for white and one for other races. In general, one of the two race dummies was significant and the other was not for each nutrient. This could be indicative of multicollinearity problems arising from too few observations on "other" races. A scarcity of observations on one classification of a dummy could give an almost complete vector of zeros, and would provide a near linear combination capable of producing severe multicollinearity (57:62).

Of the three dummies in the model for education, two or three are insignificant[1] for all but vitamin C. This could indicate several possibilities:

i) poor choice of classification groups (either ignoring relative numbers of observations in each classification or the groups chosen are not those likely to show effects on nutrition);

ii) education does not effect nutrition;

iii) education as measured by level of schooling completed may not reflect nutritional knowledge.

The life cycle variables as a group appear rather significant. However, the dummy for life cycle stage 5 (average age of children greater than 17 years) is consistently insignificant except for calcium. It is difficult to find a satisfactory explanation for this anomaly. It is possible that the life cycle variable may not be the most informative or exact method to describe family composition. Households in stage 1 (no children, housewife less than 40) and stage 2 (children under 6) consume less of all nutrients than stage 3 households (children 6 to 12 years). Stage 1 households, however, consume more of all nutrients except iron and thiamine than do stage 2 households. Stage 4 households (children 12 to 17) consume the largest amount of each nutrient except vitamin A. Households in stage 6 (no children, housewife over 40) consume the smallest amount of protein, iron, and thiamine and the second smallest amounts of vitamin A, calcium, and vitamin C.

Family size has the smallest relative standard errors, as well as the highest relative magnitude of coefficients in almost all of the six nutrients. They are all positive which is logical, in that more people require more food.[2] The meal adjustment variable has the next consistently large set of small, relative standard errors.

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1 An F-test is really necessary to distinguish whether the Education dummies as a whole are significant or not, but the information for the test is not available.

2 The size of the family can also have a negative effect on nutrition through a decrease in the per capita income of the household with an increase in members. However, these effects usually are submerged under the larger, positive effect of an increase in the required amount of food.

Its effect is positive, but is not as great a magnitude as family size. Therefore, an increase in meals at home (from guests or for family members) increases nutrient consumption, whereas a decrease in at home meals (meals missed or eaten away) logically causes a decrease.

The employment of the housewife outside the home was insignificant for the six nutrients shown in table 3.2. However, it was found to be significant and positive for fat and carbohydrate.

The authors conclude from their analysis that income transfers to alleviate nutritional deficiencies can have only a small impact. Direct food transfers would appear to be more efficient.[1] The analysis points up where deficiencies might arise, e.g., the trend to urbanization would appear to cause a decline in all nutrient intakes except vitamins A and C. The authors also suggest nutrition education programs be directed toward urban, less-educated, black households.

The other study by Chernichovsky (15) utilized unpublished summary tables from the United States 1955 Household Consumption Survey; and therefore, his analysis used aggregate data. Specifically, they consisted of cell averages for 65 food items where 72 cells were determined by division into region (North or South), urbanization (urban, rural non-farm, and rural farm), four income groups, and homemaker's education (primary, high school, or college). Household size in terms of meals eaten at home (i.e., 21 meals at home per week constitutes one person) was also known for each of the cells. The 65 foods were converted to eleven nutrients by means of a conversion matrix, resulting in a matrix of eleven nutrients by 72 observations. Regressions of the following form were derived for all eleven nutrients:

$$(3.11)\quad \ln N_{ij} = A_i + a_{1i} \ln \text{income}_j + a_{2i} \ln(F \cdot \text{size}_j) + a_{3i}\, \text{south}_j + a_{4i}\, \text{rural farm}_j + a_{5i}\, \text{rural non-farm}_j + a_{6i}\, \text{high school}_j + a_{7i}\, \text{college}_j + U_{ij}$$

$$(i=1,2,\ldots,11;\ j=1,2,\ldots,72)$$

Nutrients, family size, and income were run as continuous variables; region, urbanization, and education were set up as dummy (zero-one) variables. The results (Table 3.4) have high R^2s due to the use of grouped data (15.6).

The income elasticities (the coefficients of income since this is a double-log model) are of the same order of magnitude as Adrian and Daniel's except for calcium and vitamin C. As before, they illustrate a low sensitivity of nutrients to a change in income, the most

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1 This assumes people will eat what they are given, as well as what they would buy.

TABLE 3.4: Regression Coefficients with Home Consumption of Nutrients as Dependent Variables
(t Statistic in Parentheses)

Dependent Variable (Nutrient)	Income	Family Size	North-Urban Elem. School (Intercept)	Region South	Urbanization		Education		Adjusted R^2	F
					Rural Non-Farm	Rural-Farm	High School	College		
Calcium	.0901 (4.2103)	.8191 (6.7919)	8.8167	-.1379 (-0.5070)	.2633 (6.3293)	.0886 (2.6448)	.1998 (4.9333)	.1234 (3.7281)	.839	54
Carbo-hydrates	.0085 (0.6250)	.9135 (11.8791)	7.8833	.0579 (3.3276)	.2657 (9.9887)	.1489 (6.9906)	.0486 (1.5837)	.0308 (1.4597)	.920	118
Fat	.0836 (5.9714)	.7749 (9.7841)	6.6646	-.0641 (-3.5810)	.2227 (8.1575)	.0622 (2.8273)	.1361 (5.1165)	.0790 (3.6406)	.907	100
Food Energy	.0520 (4.3697)	.8139 (12.2760)	9.9059	.0011 (.0000)	.2420 (10.4310)	.0973 (5.2032)	.0911 (4.0310)	.0531 (2.8703)	.929	159
Iron	.0580 (2.8431)	.6380 (5.6261)	5.1646	.0000 (.0020)	.1954 (4.9343)	.0196 (0.6106)	.0410 (1.0622)	.0034 (0.1072)	.763	39
Niacin	.0493 (3.1006)	.7300 (8.1747)	5.0505	.0433 (2.1436)	.2226 (7.2039)	.0544 (2.1847)	.0213 (0.7076)	.0004 (0.0163)	.870	69
Protein	.0823 (6.6910)	.6985 (10.0939)	6.5586	-.0449 (-2.8782)	.2372 (9.9247)	.0476 (2.4792)	.0991 (4.2716)	.0559 (2.9421)	.923	124
Riboflavin	.0865 (5.0291)	.6843 (7.0474)	3.0082	-.0441 (-2.0137)	.2335 (6.9701)	.0351 (1.3048)	.1203 (3.6902)	.0680 (2.5564)	.858	63
Thiamine	.0291 (2.1716)	.7742 (10.2543)	2.9019	.1185 (6.9706)	.2690 (10.3462)	.0961 (4.5981)	-.0183 (-0.7233)	-0.0150 (-0.7246)	.923	122
Vitamin A	.1542 (6.9459)	.5130 (4.1073)	10.7470	-.1310 (4.6454)	.0229 (0.5313)	-0.0030 (-0.0864)	.1852 (4.4095)	.1279 (3.7289)	.743	30
Vitamin C	.1710 (7.0954)	.3299 (2.4601)	6.3651	.0010 (.0000)	.1011 (2.1556)	-.0313 (-0.8258)	.1377 (3.0197)	.1270 (3.3867)	.697	21

SOURCE: Dov Chernichovsky, "The Demand for Nutrition", The World Bank, 1978, (Mimeographed), p. 7, table 1.

being a 1.7% increase in vitamin C for a 10% increase in income. The author suggests there may be a downward bias for income elasticities in his model due to the fact that the nutrients pertain only to home consumption. Whereas, increases in away from home consumption may be important with increased income. He concludes, that increased income decreases the chances of many deficiencies; however, it makes one more liable to overconsume fat.

Family size along with income has one of the most significant coefficients, and that of family size is also the largest in relative magnitude. These coefficients indicate that consumption of all nutrients increases with household size, but less than proportionately except for calcium and carbohydrates (these have values insignificantly different from one). He considers that this indicates that as family size increases, the household foregoes other goods to ensure some sort of "basic diet".

Urbanization was significant except for vitamins A and C as in Adrian and Daniel. Chernichovsky found that the urbanization and region variables followed the expected pattern of food price differentials, i.e., higher prices in the North and urban areas. However, he noted the clearest pattern is that these coefficients illustrate not only price differentials, but are in line with the estimated income elasticities for nutrients and the expected higher incomes in the North. In particular, Southern households only consume more than Northern households of carbohydrates, niacin, and thiamine (which have the lowest income elasticities).

Education was found to be a significant variable except for carbohydrates, iron, niacin, and thiamine. This differs from Adrian and Daniel's results. He expects two conflicting effects of education on nutrition: a negative effect of higher education analogous to that of higher income (i.e., the homemaker desires to spend less time on food preparation) and a positive effect of greater knowledge of the desirability of a good diet. Therefore, the existence of a positive effect of high school education, then a decrease in nutrients with a college education exhibits an appropriately non-linear "total effect" for education.

Other variations of nutrient consumption functions have been studied using non-national data. Specifically, two important variants are the use of food expenditures instead of income as an explanatory variable (55) and the division of income into its sources, e.g. the "income" from food stamps (7, 40). Swanberg and Shipley (55) studied the effect of food expenditure on nutrient consumption in East Cundinamarca, Colombia. Their data were for two rural zones, one with slightly higher "income" (the potato zone) than the other (the corn zone). They ran a simple linear regression of nutrient consumption per household on food expenditure. They felt their results (Table 3.5) indicated there was little effect of expenditures on nutrient consumption except for protein and calories. However, what they did not comment on and that appears of more interest is the difference in R^2 and magnitude of the coefficients between the

TABLE 3.5: Fitted Regression Equations for the Relationship Between Consumption of Specified Nutrients Consumed and Food Expenditures for the Family Average Group[a]

Nutrient consumed	Corn zone			Potato zone		
	Intercept	Slope	R^2	Intercept	Slope	R^2
Calories	477 (6.9)	161 (15.8)	.68	793 (7.7)	126 (10.3)	.46
Protein	3.18 (3.2)	5.13 (13.6)	.61	14.2 (4.9)	4.5 (13.0)	.58
Riboflavin	.14 (2.0)	.12 (2.9)	.07	.46 (5.2)	.09 (8.3)	.36
Calcium	87 (1.4)	56 (6.4)	.25	170 (2.5)	53 (6.5)	.26
Vitamin A	286 (.9)	138 (2.9)	.07	205 (.06)	220 (5.7)	.21

SOURCE: Kenneth G. Swanberg and Elizabeth Shipley, "The Nutritional Status of the Rural Family in East Cundinamarca, Colombia", Food Research Institute Studies (Palo Alto, California: Stanford University Press) 14 (1975) p. 122, table 9.

[a]The t values are in parentheses.

zones. That is, R^2 and the magnitudes decreased for protein and calories in the potato zone, while the vitamin R^2s increased. Perhaps this is the logical result in that intakes are quite low in the corn zone for riboflavin (per capita consumption at 76% of recommended), calcium (64%) and vitamin A (28%), as well as protein and calories (69%).[1] Therefore, pure quantity (calories and protein effected more) is likely to be of more importance in the food budget than quality (the other nutrients). Whereas, in the potato zone they are almost in the acceptable range (greater than 86%)[2] for protein (at 84%) and calories (at 80%); therefore, quality in the form of the other nutrients gains in importance. The main problem with their analysis is the extraordinarily simple form of the regression. They did not even attempt to control for family size. A linear form was utilized which, although simple, implies a constant marginal propensity to consume which may not be viable even in their fairly homogeneous (by income) samples. The use of food expenditure instead of income involves all the problems of pricing home production, and obscuring what the marginal propensity to consume food out of income may be.

The second technique of dividing income into its sources has been applied to food (7) and recently to income (40). Neenan utilized household income and bonus stamp value (defined as the redemption value of the stamps minus the purchase requirement) as separate regressors (along with an interaction term for the two) in a model of NAR.[3] The results were not as expected. Specifically, for those households participating in both the food stamp and Expanded Food and Nutrition Program (EFNEP) calcium, vitamin A, and vitamin C NAR values were negatively effected by increases in bonus stamp value. Protein and iron NAR values were unaffected. These negative effects may arise from a switching away into less nutritious "luxury", junk foods, such as soda pop and candy as this bonus income increases and is forced into food consumption. This could indicate that food stamp programs could be just as poor if not worse at improving nutrition, than income increasing policies. Since a limited amount of food will be eaten, the forcing of increases in "income" into food, may simply force it into these less-nutritious foods. Whereas, even though a lower percentage of a general income increase will go to food, perhaps "luxury" spending will take place outside the food sector. Thus, forcing any increase in food expenditure to be in more basic food items.

In summary, there is no clear-cut "best" methodology to study the interactions of nutrition and economic policies. If the impact on nutrition of a specific policy is desired, Pinstrup-Andersen's method or some variant of it is definitely the most promising. Tyrrell's approach could give a better indication of intra-household distribution of nutrients. However, it has yet to be tested as has Pinstrup-Andersen's. The major difficulty in actually using either of these

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1 Percentages are from table 4 page 116 of (55).

2 Standard of the United States Interdepartmental Nutrition Committee for National Defense suggested on page 116 of (55).

3 See above for a discussion of such ratios.

models is that they utilize more data than are generally available or reliable in less developed areas. Secondly, they take more analysis of data than there is time or money available in many cases. Both of these problems being the case in this study, one of the more simple descriptive methodologies will be explored. In this area of descriptive methodologies there are more to choose from. On the basis of simplicity of models the nutrient consumption approach is preferable. Since the data are converted to nutrients first, the many food items in a household consumption survey are narrowed down to the few nutrients of interest right from the beginning. An example of such an analysis is presented in the following chapter.

CHAPTER 4

THE METHODOLOGY AND DATA

This chapter proposes a function suggested by household production theory (see pages 80-88 of the author's M.S. Thesis, Cornell University, 1979) and test it by use of United States data. The function is of the general form:

(4.1) $N_i = f_{N_i}$ (age, education, race, age-sex composition, income)

To estimate this it will first be necessary to decide upon the functional form for a calorie-income relation. The other socioeconomic variables will then be specified, amongst which the family size-composition variable is the most complicated. Along with the model for total nutrient consumption, models for illustrating the effects of home produced food on consumption will be considered. Lastly, the data utilized to test the models will be discussed.

Form of the Equations

Economic theory suggests there are two main properties that are desirable for income-food relations (47:82):

i) an initial income level below which a food is not purchased;

ii) a satiety level where consumption increases at a decreasing rate despite increases in income.

These imply that the marginal propensity to consume (MPC) will be non-constant and decreasing. Empirically, the income elasticity of demand for food has generally been found to be less than one and to decrease with an increase in income (59:26-27). To extrapolate from food to nutrients is not straightforward. There is not likely to be an income level where none of a particular nutrient is bought. However, a satiety level for most nutrients is probable. There will be changes in the quality of food eaten with an increase in income, but the quantity can only increase so much.

The semi-log form was chosen for the income-nutrient relation

on the basis of good statistical results with the test data[1] and its appropriate theoretical implications. Given the semi-log form

$$(4.2) \quad Q_i = \alpha + \beta \ln Y ,$$

the MPC (β/Y) tends to zero as income increases. However its income elasticity (β/Q_i) tends to zero as the quantity of nutrient increases and is affected by income level only through income's effect on Q_i. The semi-log form does not have a satiety level, but allows for some decrease in consumption with higher incomes.

Family Size-Composition Variable

One of the most important variables (in terms of its explanatory power) in the consumption of nutrients is the family age-sex structure. A size-composition variable should take account of both scale and size effects. If all types of people in a household could be scaled to a "standard" adult, where for example a 5-year-old child was one-third an equivalent adult, then the sum of these equivalents would be the size of the household. However, the scale in terms of how many people the food has to be divided between would be obscured. Besides taking account of these two effects, a size-composition variable should be able to be interpreted in a real-world sense.[2] That is, since the emphasis is on nutrients, it is preferable that coefficients of these variables (or some combination of them) can be compared with RDAs. There are at least four general methods of dealing with family size:

i) numerical family size;

ii) family size in equivalent units;

iii) classification of household members into several age-sex groups;

iv) life cycle variable for the household.

The use of family size is of interest only in the event of no available alternative for it obscures the true size effects described above. The usual improvement is to define a scale where the adult male is set equal to one, and family members are scaled according to their consumption relative to the adult male. Equivalent scales avoid the homogeneity hypothesis implicit in the use of the number of family members or per capita consumption (or income) values in demand analysis (47:88-89, 127).

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1 See the discussion of family size-composition variables in this chapter and appendix B for examples of test data runs.

2 In many analyses such an interpretation is unnecessary, for the size-composition variables are utilized only to allow a more reliable estimate of other parameters, however that is not the case with this analysis.

Equivalent scales can be developed,[1] such that,

$$(4.3) \quad \frac{Q_i}{N^*_r} = f_i\left(\frac{Y_r}{N^*_r}\right)$$

where

$$(4.4) \quad N^*_r = \sum_j w_j N_{jr} \; ;$$

w_j are the equivalent adult scales for people of type j; and N_{jr} are the number of j-type people in the r^{th} household. When first developed, the w_j were based mostly on nutritional criteria, and thus were most applicable to food. Nutrient equivalent scales are generally derived from RDAs per type of family member for each nutrient with the adult male's RDA as a base of one. This process provides normative scales with no basis in market behavior. A more positive approach is through estimating specific (the need of a person for a commodity) and income (decreased per capita income caused by an additional person of type j) effects.

If the concern is only for the total effect, and knowledge of the exact equivalent scales is of little value, then the simplistic approach of estimating

$$(4.5) \quad Q_i = f(Y, N_j)$$

is suggested (57:66-67), where N_j are m classification variables by age and sex, such that N_j is the number of j type persons in the household. An example classification system is shown in Table 4.1. In the methods above the problem of scale has been obscured. In the former income scales were assumed away, in the latter they are simply ignored. One method that has been used (57:69) instead of 4.5 is

$$(4.6) \quad Q_i = f\left(\frac{Y}{N}, N_j\right)$$

where N is the number of household members. If a semi-log form is assumed, then[2]

$$(4.7) \quad Q_i = \alpha + \beta \ln\left(\frac{Y}{N}\right) + \sum_j \gamma_j N_j$$

The specific effect would then be γ_j, where if the m^{th} type person is the base

$$(4.8) \quad w_j = \gamma_j / \gamma_m \qquad j=1,\ldots,m-1$$

The total effect of the j^{th} type of person would be

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1 This analysis follows mostly from Prais and Houthakker's chapters 9 and 10 (47).

2 This development paraphrases that of Rayner, et al. in (57:69).

TABLE 4.1

Definition of the Family Classification Variable: An Example

C_1	infants less than one year
C_2	children 1 through 3 years
C_3	children 4 through 6 years
C_4	children 7 through 10 years
C_5	males 11 through 13 years
C_6	males 15 through 18 years
C_7	males 19 through 22 years
C_8	females 11 through 13 years
C_9	females 15 through 18 years
C_{10}	females 19 through 22 years
C_{11}	adults 23 through 50 years
C_{12}	adults 51 and older

(4.9) $\delta Q_i / \delta N_j = \gamma_j - \beta/N$

Therefore, equation 4.6 may be the most direct, simplest manner to take account of size and scale effects without having to derive equivalent scales directly.[1]

An entirely different concept in size-composition variables is the life-cycle variable. A family is considered to follow a definite pattern from newlyweds, young families, families with older children, to older couples. Dummy (zero-one) variables are set up such that a household is placed in one of about six life cycle stages, as exemplified in Table 4.2. The life cycle variable has its basis in sociological theories of the stages of the household (18, 28). There are many difficulties in devising appropriate and useful stages, namely,

i) how can one "divide up" the continuum of family life;

ii) what is a useful division for considering food consumption effects;

iii) how many stages can be utilized given the limitations of degrees of freedom and time for interpretation;

iv) does one classify first by ages of the father or mother or both, and should one consider children in terms of their number, average age, or age of the eldest?

The ramifications are many, which makes any one classification rather tenuous. Numerical family size is usually included with the life-cycle variable in regressions. This is because the life cycle takes account of composition (size) effects, whereas family size is necessary for scale effects.

Preliminary regressions were run on a subset of the data (to be discussed at the end of this chapter) to compare three size-composition variables

i) family size in equivalent nutrients defined by use of RDAs;

ii) a classification variable, as in Table 4.1;

iii) a life cycle variable, as in Table 4.2, plus family size.

The results illustrated by way of F-tests, that the life cycle variable was insignificant except for the family size component. The other two were equally valid statistically, but the classification variable appears to have a more directly applicable interpretation.

Therefore, it was decided that family size and composition would

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1 More involved methods for deriving equivalent scales do exist, particularly for continuous scales, see (12).

TABLE 4.2: Stage of the Household in the Family Life Cycle

L_0[a]	stage 3:	average age of children 6-12 years
L_1	stage 1:	no children & housewife 40 years
L_2	stage 2:	average age of children 6 years
L_3	stage 4:	average age of children 12-17 years
L_4	stage 5:	average age of children 17 years
L_5	stage 6:	no children & housewife 40 years

SOURCE: J. Adrian and R. Daniel, "Impact of Socioeconomic Factors on Consumption of Selected Food Nutrients in the United States", American Journal of Agricultural Economics 58 (February 1976): 33.

[a]In actual regressions the middle stage, here designated as L_0, is left out to avoid singularity.

enter the model in the form of a classification variable, plus dividing income by family size, as postulated in equation 4.6. The classification variables differ by nutrient on the basis of RDA classifications. If a nutrient has several RDA classifications, indicating a large variance in intake by type of person, then the classification variable also has several classifications. The definition of the classification variable, C_j, and those used for each nutrient are in Tables 4.3 and 4.4. Several forms were tested for most nutrients before arriving at those in the table.

Other Socioeconomic Variables

The other socioeconomic variables that were thought to be of importance either statistically as shown by testing or theoretically are race (R), education (E), and employment of the homemaker (F). Race and employment of the homemaker were set up as zero-one dummy variables where one indicated white race and employed homemaker, respectively. Education was specified to have a curvilinear relationship with nutrient consumption. For most nutrients, as education increased consumption increased; but after a certain point, more education caused a decrease in consumption. Therefore, a quadratic form was used for education. Education was defined as highest grade completed and represented by two terms: education (E) and education squared (E^2 or ESQ).

One other variable was utilized, a meal adjustment variable (J). Since the survey collected data on total meals eaten at home[1] including that of guests and hired help and did not include meals eaten away from home, a variable to adjust for this was required. Adrian and Daniel's (1:33) suggestion of J equal to total meals eaten at home minus the quantity 21 (total possible meals eaten by one person per week) times the number of family members was adopted.

Modeling Home versus Purchased Nutrients

Since the emphasis of this work is on the farm family, it would logically be of interest to observe differences (if any) between nutrients from home produced food and those from purchased food. There are two views of the demand functions for purchased food:

i) demand is conditional on home produced food, which is exogenously determined;

ii) purchased and home produced food are separately determined by the same variables.

The conditional demand approach can be elucidated through considering consumption of home produced nutrients, Q_i^H, as controlled exogenously by the time left over from other farm chores and other

1 Snacks eaten at home were included in the total consumption of the household, but were not counted as a meal.

TABLE 4.3

Definition of the Family Classification Variable for the Model

C_1 .....Infants less than one year
C_2 .....Children 1 through 3 years
C_3 .....Children 4 through 6 years
C_4 .....Children 7 through 10 years
C_5 .....Males 11 through 14 years
C_6 .....Males 15 through 18 years
C_7 .....Males 19 through 22 years
C_8 .....Males 23 through 50 years
C_9 .....Males 51 and older
C_{10}.....Females 11 through 14 years
C_{11}.....Females 15 through 18 years
C_{12}.....Females 19 through 22 years
C_{13}.....Females 23 through 50 years
C_{14}.....Females 51 and older
C_{15}.....Males 23 and older
C_{16}.....Females 23 and older
C_{17}.....Children 11 through 14 years
C_{18}.....Children 15 through 18 years
C_{19}.....Adults 19 through 50 years
C_{20}.....Adults 51 and older
C_{21}.....Males 11 through 18 years
C_{22}.....Males 19 through 50 years
C_{23}.....Females 11 through 18 years
C_{24}.....Infants through 3 years
C_{25}.....Children 4 through 10 years
C_{26}.....Males 11 through 22 years
C_{27}.....Females 11 through 22 years
C_{28}.....Infants through 6 years
C_{29}.....Children 7 through 14 years
C_{30}.....Children 15 through 22 years

TABLE 4.4

Family Classification Variable by Nutrient

Calories	C_1 through C_{14}
Protein	C_1 through C_{12}, C_{15}, C_{16}
Fat	C_1 through C_{14}
Carbohydrates	C_1 through C_{14}
Calcium	C_1 through C_4, C_{18} through C_{21}
Iron	C_1 through C_4, C_{21} through C_{23}, C_{12} through C_{14}, C_9
Vitamin A	C_{24} through C_{27}, C_{15}, C_{16}
Riboflavin	C_1 through C_4, C_{26}, C_{27}, C_{15}, C_{16}
Vitamin C	C_{28} through C_{30}, C_{19}, C_{20}

such items. Given this Q_i^H, the total consumption of nutrients, Q_i, depends also on the socioeconomic factors (denote them as X) discussed above. Therefore, the demand function would be of the form

$$(4.10) \quad Q_i = \alpha X = \beta Q_i^H$$

Since

$$(4.11) \quad Q_i \equiv Q_i^H + Q_i^P$$

where Q_i^P are purchased nutrients, 4.10 becomes

$$(4.12) \quad Q_i^P = \alpha X + (\beta-1)Q_i^H$$

Therefore, purchased nutrients would be a function of the predetermined level of Q_i^H and socioeconomic variables.

The second view of Q_i^P is that the level is determined by a set of socioeconomic variables that also influence Q_i^H. This implies

$$(4.13) \quad Q_i^P = \gamma X$$

and

$$(4.14) \quad Q_i^H = \delta X$$

If

$$(4.15) \quad Q_i = \varepsilon X$$

was also estimated, then it would be necessary to constrain

$$(4.16) \quad \varepsilon = \gamma + \delta$$

due to definition 4.11. The logical method to do this would be to estimate 4.13 and 4.15 and simply define

$$(4.17) \quad \hat{\delta} = \hat{\varepsilon} - \hat{\gamma}$$

where a ^ indicates an estimate.

This dichotomy of views on the decision process involved in home versus purchased nutrients is not easily resolved. If home production is due to farm production relations, and purchased food simply fills the gap between home production and demand, then the conditional approach is appropriate. However, if home production and purchases are both separately influenced by the same set of socioeconomic variables, then the constrained approach is necessary.

The Models

There are two types of models to be expressed:

i) the one to describe total nutrient consumption;

ii) those to illustrate the effects of home produced food.

In order to study total nutrient consumption and how it is affected by socioeconomic variables, the following equation was used

$$(4.18)\quad Q_i^T = \alpha + \beta_1 \ln(Y/N) + \beta_2 F + \beta_3 E + \beta_4 E^2 + \beta_5 R + \beta_6 J + \gamma_{ij} C_j + \varepsilon_i$$

where variables are defined as above and in Table 4.5.

The conditional demand approach to home-produced nutrients (see above) can be expressed as

$$(4.19)\quad Q_i^P = \alpha + \beta_1 \ln(Y/N) + \beta_k Z + \lambda_1 Q_i^H + \lambda_2 Q_i^O + \varepsilon_i$$

where $\beta_k Z$ is a matrix of the last six terms of 4.18 (excluding the error term), Q_i^H is the consumption of nutrient i from home produced food for one week, Q_i^O is the consumption of nutrient i from other than purchased or home-produced sources. The separately determined case of home-produced and purchased nutrients was investigated utilizing

$$(4.20)\quad Q_i^P = \alpha + \beta_1 \ln(Y/N) + \beta_k Z + \varepsilon_i \quad \text{and}$$

$$(4.21)\quad Q_i^H = \delta + \mu_1 \ln(Y/N) + \mu_k Z + \varphi_i$$

The constrained approach suggested above is not possible with the available data because

$$(4.22)\quad Q_i^T = Q_i^P + Q_i^H + Q_i^O$$

This is not the same as 4.11 which was assumed in order to derive the constrained approach. Equation 4.22 implies the coefficients of 4.18 should equal the sum of 4.20 and 4.21 except for the difference caused by Q_i^O. Therefore, it is valid to estimate 4.18, 4.20, and 4.21 separately as long as there is the factor of Q_i^O to provide a gap.

The Data

The USDA 1965-66 Household Consumption Survey was conducted over four seasons, four regions, and three urbanization groups.[1] The spring data were the most thorough and thus chosen for this study. Since farm households, particularly low-income ones, are of interest in this analysis, the rural farm, southern households were utilized. This was predicated upon there being twice as many households in the

1 U.S. Department of Agriculture, Agricultural Research Service, Household Food Consumption Survey 1965-66, Reports 1-10 (Washington, D.C.: Government Printing Office, 1970); U.S. Department of Agriculture, Agricultural Research Service, Spring Data 1965-66 Computer Tape.

TABLE 4.5

Definition of Terms in the Final Models

C_j . . . . . Family classification variable as described in tables 5.3 and 5.4

E . . . . . Highest grade completed in school

E^2 . . . . . E squared (also note ESQ)

F . . . . . Employment status of the homemaker (one for employed)

J . . . . . Meal adjustment to account for home versus guest, skipped, and away meals (J=TM - (N) (21), where TM is total meals served)

N . . . . . Family size

Q_i^T . . . . . Quantity of the i^{th} nutrient consumed/household/week (also noted by T preceding the following)

Q_1 Calories (CAL)
Q_2 Protein (grams) (PRO)
Q_3 Fat (grams) (FAT)
Q_4 Carbohydrate (grams) (CHO)
Q_5 Calcium (milligrams) (CA)
Q_6 Iron (milligrams) (FE)
Q_7 Vitamin A (tens of international units) (VA)
Q_8 Riboflavin (milligrams) (RIB)
Q_9 Vitamin C (milligrams) (VC)

Q_i^P . . . . . Quantity of the i^{th} nutrient from purchased sources

Q_i^H . . . . . Quantity of the i^{th} nutrient from home production

Q_i^O . . . . . Quantity of the i^{th} nutrient from other sources

R . . . . . Race (one for white)

X^T . . . . . Total expenditures on food/week ($)

X^P . . . . . Expenditures for purchased food/week ($)

Y . . . . . Annual household disposable income in thousands of dollars (utilized midpoints of income class groupings except for $25,000 and above group where $25,000 was used)

ε_i, φ_i . . . . . Error terms for the i^{th} nutrient equation

under $3,000 income level in the South than in any of the other regions.[1] It was thought best to limit the study to one region since it was necessary to assume prices to be constant across all households.

As can be seen from Tables 4.6 and 4.7, the largest number of poor diets are in the rural farm South. In fact only 43% of the diets in this region are listed as good which is the smallest percentage by region-urbanization group other than the rural, non-farm West at 39%. From Table 4.8 it can be observed that the problem nutrients are likely to be calcium, vitamin A, and vitamin C (ascorbic acid). All of these appear to be an even larger problem for households whose income is under $3,000 (see Table 4.9). Rural farm households have the lowest number of diets meeting vitamin A and C allowances, but they also have the highest number of diets meeting the calcium allowances (69; 11:4).

Since the Household Consumption Survey was conducted by the USDA, farm households were purposely over-sampled by approximately five times the actual population so that a more thorough analysis could be made of these households. In order to study the country as a whole, the USDA used subsets of appropriate size drawn from these large samples. For the South this small sample consisted of 167 households (of which 159 had complete data). It is this sample that was used for testing and reformulating models in this study. Once models were completely set, the final regressions utilized the supplementary set of 633 observations (of which 618 were valid).

The data collected on each household included a recall by the homemaker of all food consumed in the household during the week preceding the interview. For each of these food items a conversion factor of quantity of food into quantities of nutrients was provided. To derive the consumption of a nutrient for the household per week it was necessary to multiply each food consumed by its conversion factor and sum over all foods. This was done for nine nutrients: calories, protein, fat, carbohydrate, calcium, iron, vitamin A, riboflavin, ascorbic acid. These were chosen largely on a basis of availability of data, but partially on expectation of problem nutrients. Carbohydrate and fat are not nutrients *per se*; they were included to observe changes in the composition of the diet. There are no RDAs for fat and carbohydrate.

The income data consisted of an income class designation for each household. For the purposes of the regressions where a specific point is needed, it was necessary to compromise by using the midpoint

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1 Specifically, 40% of rural farm households in the South earned less than $3,000 income, as opposed to 20%, 25%, and 18% for the Northeast, North Central, and Western regions, respectively. These data were derived from U.S. Department of Agriculture, Agricultural Research Service, Household Food Consumption Survey 1965-66, Reports 7-10 (Washington, D.C.: Government Printing Office, 1970), p. 15, table 1.

TABLE 4.6

Diets at Three Levels of Quality[a]

By Urbanization and Region (percent)

	Good	Fair	Poor
Urban			
Northeast	54	29	17
North Central	46	30	24
South	49	29	22
West	53	29	18
Rural Nonfarm			
Northeast	48	32	20
North Central	52	30	18
South	46	28	26
West	39	44	17
Rural Farm			
Northeast	53	34	13
North Central	52	30	18
South	43	27	30
West	56	31	13

SOURCE: U.S. Department of Agriculture, Agricultural Research Service, Household Food Consumption Survey 1965-66, Report No. 9 (Washington, D.C.: Government Printing Office, 1970), p. 7.

[a]The quality is defined as the diet for the household for one week meeting RDAs (1963) for 7 nutrients (good); two-thirds RDA for 1 to 7 nutrients, but below RDA for 1 to 7 (fair); below two-thirds RDA for 1 to 7 nutrients (poor).

TABLE 4.7

Poor Diets[a] Among Households with Incomes Under $3,000 by Urbanization and Region (percent)

	Urban	Rural Nonfarm	Rural Farm
Northeast	32	35	17
North Central	41	31	28
South	38	42	43
West	26	26	23

SOURCE: U.S. Department of Agriculture, Agricultural Research Service, Household Food Consumption Survey 1965-66, Report No. 9 (Washington, D.C.: Government Printing Office, 1970), p. 7.

[a]Households with poor diets are those with consumption for one week that is below two-thirds RDA (1963) for 1 to 7 nutrients. It is not synonymous with serious hunger and malnutrition.

TABLE 4.8

Percentage of RDA met for Nutrients by Region

Nutrient	Diets meeting allowances			
	Northeast	North Central Region	South	West
	Pct.	Pct.	Pct.	Pct.
All nutrients	53	48	48	52
Protein	95	95	94	95
Calcium	69	69	70	69
Iron	89	90	91	91
Vitamin A value	76	73	72	79
Thiamine	91	92	93	90
Riboflavin	95	94	93	94
Ascorbic acid	79	71	68	77

TABLE 4.9

Percentage of Diets Below RDAs for Certain Nutrients

by Income Level

Income	Diets below allowances for		
	Calcium	Vitamin A value	Ascorbic acid
	Pct.	Pct.	Pct.
Under $3,000	32	39	46
$3,000 - $4,999	36	30	38
$5,000 - $6,999	24	22	23
$7,000 - $9,999	25	20	18
$10,000 and over	25	14	10

SOURCE: U.S. Department of Agriculture, Agricultural Research Service, Household Food Consumption Survey 1965-66, Report No. 9 (Washington, D.C.: Government Printing Office, 1970), pp. 7, 5.

of the class. The number of people in the household along with their ages and sex were directly available. The latter was converted into the C_j discussed above. The education in terms of the highest grade achieved by the housewife was provided. The race of the household was also expressed as that of the housewife.

This chapter has developed the form of the equations and the socioeconomic variables to be utilized. This allowed a general model of nutrient consumption to be constructed. Secondly, two variants of a model to express the effects of home produced nutrients were suggested. The next chapter will present the results and conclusions of this example study.

CHAPTER 5

RESULTS AND CONCLUSIONS

This chapter discusses the regression results from the models put forth in chapter 4 (see Tables 5.1 through 5.9). General results on a variable by variable basis will be discussed first. Secondly, the results will be considered in terms of the models as a whole. Conclusions will be drawn from the models and on how well they performed. The last section will consider conclusions from the general analysis of nutrition's role in economic development.

Income

The income variable is positive for all except calcium and carbohydrate in the total nutrient equation (4.18). Equations 4.20 and 4.21 illustrate that income increases have a negative effect on all home produced nutrients and a positive effect on purchased nutrients. It appears that when total nutrients are considered, the home production (negative) effect predominates in calcium and carbohydrates. This is probably due to the influence of home produced corn and milk for lower income classes. The standard error of the income variable also illustrates the dichotomy of home and purchased effects. The t-values are relatively high for income in equations 4.20 and 4.21, however in the total nutrient equation the t-values drop as low as 0.2. Apparently, the contradictory effects of income on home produced and purchased nutrients result in an increased standard error for income on total nutrients.

The income elasticities for calorie and protein from equations 4.18 and 4.19 are shown in Table 5.10. They are very low for total calories and protein becoming even lower as income increases. Those for purchased calories show a 0.02 to 0.05 percent increase in consumption with a one percent increase in income. The elasticities for purchased protein are higher ranging from 0.03 to 0.06. These low elasticities indicate that income subsidies are an inefficient mechanism for improving nutrition in a high income country like the United States. It is of interest though, that the elasticities of the low income group for purchased nutrients are twice that of the high income group.

TABLE 5.1

Calories: Results of Equations 4.18 through 4.21

Independent Variable	TCAL (4.18)		PCAL (4.19)		PCAL (4.20)		HCAL (4.21)		TCAL (4.18) Less than $3,000 Income	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	394	0.17	4503	2.21	6335	3.08	- 5269	3.63	- 14287	2.54
F	- 53	0.02	- 242	0.08	- 396	0.13	127	0.06	9250	1.54
E	1729	0.91	379	0.22	43	0.02	2171	1.78	- 4011	1.38
ESQ	- 52	0.51	17	0.18	34	0.37	- 109	1.67	335	1.87
R	10250	2.64	- 1278	0.36	- 5580	1.59	16170	6.51	7416	1.38
J	1038	12.55	830	11.03	739	9.86	268	5.08	1192	8.08
C1	3399	.52	3732	0.65	3937	0.67	- 334	0.08	- 17019	1.70
C2	13275	4.37	10846	4.01	9582	3.48	2816	1.45	15612	2.91
C3	5058	1.76	4994	1.95	5192	1.99	459	0.25	- 5115	1.12
C4	19088	9.33	17469	9.55	16537	8.92	1726	1.32	7594	2.01
C5	30147	9.32	25306	8.73	23085	7.87	6102	2.95	25041	4.26
C6	20123	7.09	15569	6,11	14057	5.47	6698	3.69	10923	2.36
C7	7707	1.72	7918	1.99	8317	2.05	236	0.08	3788	0.55
C8	26865	7.26	20724	6.25	18285	5.45	8370	3.54	19568	3.32
C9	24379	6.34	17809	5.17	15296	4.39	9113	3.71	13283	2.28
C10	21551	6.53	18577	6.32	17584	5.87	4362	2.07	17888	2.98
C11	12717	4.39	12099	4.71	11765	4.48	696	0.38	9253	1.94
C12	19324	3.96	17105	3.95	16426	3.72	3359	1.08	17834	2.63
C13	20353	5.16	14752	4.16	13060	3.65	8518	3.38	25447	4.40
C14	11623	2.88	2902	0.79	- 85	0.02	12678	4.91	12461	2.06
HCAL	--	--	0.28	4.89	--	--	--	--	--	--
OCAL	--	--	0.55	2.28	--	--	--	--	--	--
Intercept	3906		13337		14520		- 17106		62036	
R^2		.58		.55		.53		.20		.61

TABLE 5.2

Protein: Results of Equations 4.18 through 4.21

Independent Variables	TPRO (4.18)		PPRO (4.19)		PPRO (4.20)		HPRO (4.21)		Less than $3,000 Income TCAL (4.18)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	89.41	1.26	161.52	2.57	205.64	3.13	- 101.44	1.90	-478.72	2.55
F	2.89	0.03	- 2.66	0.03	- 5.65	0.06	1.14	0.01	286.87	1.42
E	5.83	0.10	- 7.31	0.14	- 17.09	0.31	47.14	1.06	-106.18	1.09
ESQ	2.32	0.73	3.08	1.09	3.63	1.23	2.46	1.03	11.55	1.93
N	512.11	4.26	154.47	1.40	- 70.69	0.63	607.42	6.70	229.61	1.28
J	30.31	11.83	23.67	10.21	19.59	8.24	9.44	4.89	32.07	6.47
C1	82.58	0.41	57.13	0.32	39.30	0.21	73.04	0.48	-272.13	0.83
C2	475.14	5.08	386.65	4.64	335.27	3.86	78.72	1.12	474.75	2.66
C3	216.20	2.43	222.47	2.83	224.81	2.72	15.91	0.24	- 41.52	0.28
C4	520.34	8.54	461.46	8.53	426.34	7.54	67.90	1.48	96.01	0.77
C5	812.90	8.06	679.97	7.60	598.49	6.40	189.46	2.49	529.14	2.69
C6	618.15	7.05	459.88	5.85	359.53	4.42	280.40	4.24	329.63	2.15
C7	260.15	1.87	214.70	1.74	185.36	1.43	89.14	0.85	246.03	1.08
C10	686.20	6.66	604.62	6.64	553.39	5.79	136.50	1.76	591.69	2.94
C11	375.64	4.19	337.22	4.26	314.53	3.78	40.64	0.60	231.10	1.45
C12	489.03	3.20	419.39	3.11	374.74	2.64	131.47	1.14	235.54	1.04
C15	659.77	6.38	468.59	5.07	349.67	3.64	300.85	3.86	487.54	2.81
C16	400.98	3.63	222.09	2.24	107.45	1.05	336.97	4.05	502.21	2.85
HPRO	--	--	- 0.38	8.02	--	--	--	--	--	--
OPRO	--	--	- 0.34	1.96	--	--	--	--	--	--
Intercept	- 54.98		122.04		249.30		- 561.53		1685.08	
$\bar{R}^2$		.50		.44		.38		.17		.47

TABLE 5.3

Fat: Results of Equations 4.18 through 4.21

Independent Variables	TFAT (4.18)		PFAT (4.19)		PFAT (4.20)		HFAT (4.21)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	208.20	1.70	411.28	3.82	576.15	4.98	- 330.81	3.14
F	99.20	0.56	80.05	0.52	61.14	0.36	26.75	0.17
E	79.23	0.77	14.18	0.16	- 31.39	0.32	115.44	1.31
ESQ	- 0.49	0.09	2.46	0.51	4.45	0.86	- 5.33	1.13
R	719.49	3.43	71.56	0.38	- 401.23	2.03	1125.21	6.24
J	49.27	11.05	38.79	9.81	30.69	7.28	17.63	4.60
C1	255.35	0.73	260.71	0.85	273.95	0.83	2.90	0.01
C2	552.78	3.38	457.49	3.20	374.06	2.42	147.23	1.05
C3	262.26	1.69	217.46	1.61	199.91	1.36	97.65	0.73
C4	742.37	6.72	695.21	7.20	643.71	6.17	59.47	0.63
C5	1334.76	7.64	1042.56	6.75	793.76	4.81	460.79	3.07
C6	981.45	6.41	718.68	5.32	545.20	3.77	480.28	3.65
C7	505.83	2.10	567.32	2.70	623.31	2.74	- 92.19	0.44
C8	1187.30	5.95	872.92	4.98	627.42	3.33	524.84	3.06
C9	981.69	4.73	694.65	3.82	489.72	2.50	504.40	2.83
C10	1015.81	5.70	807.78	5.18	669.58	3.98	379.11	2.47
C11	655.67	4.20	604.30	4.44	571.69	3.87	95.61	0.71
C12	996.45	3.79	847.30	3.70	734.60	2.95	253.97	1.12
C13	1013.14	4.76	738.98	3.96	556.65	2.77	499.36	2.73
C14	760.36	3.49	265.31	1.38	- 94.35	0.46	861.79	4.60
HFAT	--	--	- 0.42	10.21	--	--	--	--
OFAT	--	--	- 0.67	2.74	--	--	--	--
Intercept	- 713.91		- 135.35		215.18		- 1098.66	
$\bar{R}^2$		.47		.46		.36		.16

TABLE 5.4

Carbohydrate: Results of Equations 4.18 through 4.21

Independent Variables	TCHO (4.18)		PCHO (4.19)		PCHO (4.20)		HCHO (4.21)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	- 446	1.50	75	0.27	123	0.45	- 500	4.37
F	- 187	0.43	- 178	0.44	- 186	0.46	- 24	0.14
E	280	1.12	111	0.48	136	0.59	232	2.41
ESQ	- 15	1.13	- 5	0.40	- 6	0.48	- 13	2.52
R	666	1.31	- 178	0.37	- 199	0.42	907	4.63
J	120	11.06	99	9.65	96	9.61	19	4.54
C1	153	0.18	386	0.49	386	0.49	- 261	0.80
C2	1634	4.12	1316	3.57	1270	3.45	275	1.80
C3	462	1.23	635	1.82	660	1.89	- 150	1.04
C4	2660	9.94	2414	9.67	2367	9.55	194	1.88
C5	3793	8.96	3490	8.88	3463	8.84	291	1.78
C6	2226	6.00	1981	5.75	1985	5.78	283	1.98
C7	551	0.94	490	0.90	539	1.00	155	0.69
C8	3392	7.01	2804	6.20	2792	6.23	637	3.41
C9	3335	6.63	2509	5.31	2468	5.30	853	4.40
C10	2495	5.77	2426	6.07	2431	6.08	86	0.52
C11	1356	3.58	1431	4.07	1409	4.02	- 122	0.83
C12	2059	3.23	1989	3.36	2029	3.43	148	0.60
C13	2272	4.40	1636	3.37	1667	3.49	766	3.85
C14	813	1.54	138	0.28	178	0.36	824	4.05
HCHO	--	--	- 0.41	--	--	--	--	--
OCHO	--	--	- 0.39	--	--	--	--	--
Intercept	2301		2735		2397		- 1080	
$\bar{R}^2$		.58		.56		.56		.18

TABLE 5.5

Calcium: Results of Equations 4.18 through 4.21

Independent Variables	TCA (4.18)		PCA (4.19)		PCA (4.20)		HCA (4.21)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	- 2012	1.88	325	0.38	1033	1.19	- 2785	3.31
F	- 391	0.25	- 692	0.56	- 640	0.50	- 310	0.25
E	93	0.10	95	0.13	- 78	0.11	800	1.14
ESQ	8	0.16	22	0.58	34	0.87	- 53	1.40
R	11389	6.32	5728	3.94	3816	2.61	7668	5.41
J	330	8.46	251	8.11	230	7.29	82	2.67
C1	- 1116	0.36	- 1245	0.52	- 1283	0.52	147	0.06
C2	7838	5.48	5267	4.62	4792	4.14	1653	1.47
C3	349	0.26	898	0.84	948	0.86	- 115	0.11
C4	5029	5.29	3878	5.15	3654	4.74	795	1.06
C17	7609	6.80	6006	6.79	5565	6.14	1706	1.94
C18	5829	6.04	4742	6.23	4466	5.72	1050	1.38
C19	6213	6.20	4646	5.85	4053	5.00	2415	3.07
C20	5872	5.36	3004	3.42	1983	2.24	4129	4.79
HCA	--	--	- .25	6.08	--	--	--	--
OCA	--	--	- .04	0.39	--	--	--	--
Intercept	4734		1948		2343		- 2443	
$\bar{R}^2$		.37		.36		.32		.11

TABLE 5.6

Iron: Results of Equations 4.18 through 4.21

Independent Variables	TFE (4.18)		PFE (4.19)		PFE (4.20)		HFE (4.21)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	2.98	0.19	20.34	1.44	23.81	1.69	- 17.84	2.07
F	- 3.14	0.14	- 8.84	0.43	- 9.98	0.49	5.86	0.47
E	5.37	0.40	- 2.96	0.25	- 4.19	0.36	12.42	1.72
ESQ	- 0.07	0.10	0.31	0.48	0.36	0.57	- 0.57	1.48
R	- 153.96	2.01	- 30.07	1.22	- 45.37	1.91	100.17	6.88
J	6.31	10.92	4.65	8.81	4.32	8.43	1.77	5.64
C1	61.22	1.35	61.69	1.53	61.95	1.54	0.99	0.04
C2	107.00	5.07	81.74	4.33	76.28	4.07	22.25	1.94
C3	67.05	3.33	56.91	3.20	55.23	3.09	13.51	1.24
C4	116.52	8.26	99.82	7.95	96.48	7.71	17.19	2.24
C21	150.85	10.91	112.59	8.92	105.76	8.62	46.80	6.23
C22	109.92	5.41	79.06	4.36	73.37	4.07	36.05	3.27
C23	95.08	6.38	85.94	6.51	84.16	6.37	9.93	1.23
C12	94.22	2.76	64.24	2.12	59.11	1.95	38.72	2.09
C13	91.34	3.32	57.73	2.34	52.43	2.14	47.44	3.17
C9	111.46	4.45	70.52	3.15	62.69	2.82	45.39	3.33
C14	68.96	2.44	10.72	0.42	0.91	0.04	76.58	4.99
HTE	--	--	- 0.15	2.33	--	--	--	--
OTE	--	--	- 0.24	0.90	--	--	--	--
Intercept	80.16		160.61		171.69		-128.09	
$\bar{R}^2$		.51		.47		.46		.20

TABLE 5.7

Vitamin A: Results of Equations 4.18 through 4.21

Independent Variables	TVA (4.18)		PVA (4.19)		PVA (4.20)		HVA (4.21)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln (Y/N)	1324	1.69	2537	4.91	2820	5.41	- 1707	2.59
F	967	0.84	786	1.05	836	1.10	- 17	0.02
E	- 637	0.97	- 554	1.28	- 754	1.73	534	0.97
ESQ	60	1.69	60	2.59	71	3.02	- 31	1.05
R	6151	4.60	2070	2.34	1723	1.94	3942	3.52
J	210	7.37	104	5.47	94	4.98	105	4.39
C24	2330	2.83	1235	2.25	1436	2.63	184	0.27
C25	2298	4.87	1473	4.73	1482	4.74	560	1.42
C26	3387	5.71	2121	5.43	2034	5.17	1161	2.33
C27	3541	5.34	2830	6.52	2777	6.31	665	1.20
C15	4104	3.58	2003	2.66	1668	2.19	2494	2.60
C16	2236	1.87	- 42	0.05	- 425	0.54	2763	2.76
HVA	--	--	- 0.13	4.00	--	--	--	--
OVA	--	--	- 0.32	2.10	--	--	--	--
Intercept	- 3804		- 4225		- 3681		- 1316	
$\bar{R}^2$		.21		.26		.23		.09

TABLE 5.8

Riboflavin: Results of Equations 4.18 through 4.21

Independent Variables	TRIB (4.18)		PRIB (4.19)		PRIB (4.20)		HPIB (4.21)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	0.24	0.14	3.71	2.72	5.60	3.83	- 4.67	3.06
F	0.21	0.08	- 0.03	0.01	0.02	0.01	- 0.48	0.22
E	0.06	0.00	- 0.02	0.02	- 0.33	0.27	1.32	1.04
ESQ	0.05	0.62	0.07	1.10	0.09	1.40	- 0.09	1.30
R	14.39	5.14	4.88	2.06	- 1.05	0.42	15.86	6.12
J	0.70	11.58	0.53	10.65	0.44	8.30	0.22	3.97
C1	2.94	0.62	2.86	0.74	2.61	0.63	1.00	0.23
C2	12.87	5.87	9.50	5.30	8.15	4.25	2.38	1.19
C3	3.29	1.57	4.06	2.39	4.25	2.32	- 0.05	0.03
C4	11.33	8.03	10.20	8.92	9.77	7.92	0.65	0.51
C26	15.08	11.93	11.68	11.25	9.70	8.77	5.11	4.43
C27	10.19	7.18	9.35	8.15	8.95	7.21	0.88	0.68
C15	17.26	7.08	11.51	5.77	8.17	3.83	8.64	3.89
C16	7.52	2.96	3.27	1.57	0.32	0.14	8.54	3.68
HRIB	--	--	- 0.38	10.38	--	--	--	--
ORIB	--	--	- 0.19	1.77	--	--	--	--
Intercept	2.93		1.71		3.50		- 9.24	
$\bar{R}^2$		.48		.47		.38		.15

TABLE 5.9

Vitamin C: Results of Equations 4.18 through 4.21

Independent Variables	TVC (4.18)		PVC (4.19)		PVC (4.20)		HVC (4.21)	
	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
ln(Y/N)	307	3.12	494	6.06	541	6.61	- 248	3.60
F	112	0.78	40	0.33	21	0.17	42	0.42
E	61	0.74	0.36	0.01	- 14	0.20	115	2.00
ESQ	0.25	0.06	3.11	0.85	4	1.02	- 6	1.88
R	698	4.21	351	2.55	264	1.91	376	3.24
J	25	7.01	16	5.26	13	4.49	11	4.20
C28	86	1.15	77	1.23	73	1.17	- 29	0.54
C29	536	9.13	398	8.07	362	7.41	126	3.06
C30	253	3.26	221	3.47	213	3.30	29	0.53
C19	348	3.55	169	2.07	125	1.53	251	3.67
C20	407	4.03	102	1.20	27	0.32	383	5.43
HVC	--	--	- 0.20	4.15	--	--	--	--
OVC	--	--	- 0.22	1.34	--	--	--	--
Intercept	- 1148		- 1031		- 1006		- 271	0.79
$\bar{R}^2$		.22		.24		.22		.12

TABLE 5.10

		Income Elasticities[a]			
	Income ($)	2,500	5,500	8,500	10,500
Eqn.5.21	TCAL	.0040	.0039	.0038	.0037
	TPRO	.0274	.0230	.0192	.0176
Eqn.5.22	PCAL	.046	.035	.027	.024
	PPRO	.060	.042	.031	.027

[a]All elasticities were calculated at the mean of the data except for income, expenditures, and family size[b] which vary by income level and thus imply that quantity varies by income level.

[b]Family size by income level is from U.S. Department of Agriculture, Agricultural Research Service, Household Food Consumption Survey 1965-66, Report no. 4 (Washington, D.C.: Government Printing Office, 1970), p. 6, table 1.

Employment of the Homemaker

The employment of the homemaker (F) had universally low t-values (below 1.0). For total and purchased nutrients, the fact the homemaker was employed decreased consumption of all nutrients except fat and vitamin A. Since vitamin A is oil soluble and found in animal sources in conjunction with fat (i.e. eggs and butter), it is logical that these nutrients would tend to move in unison. The employment of the homemaker has the contradictory effects of increasing income[1] (allowing more nutrients to be bought) and decreasing time available for food preparation (possibly decreasing the nutritional quality). With the evidence from the regressions it would appear that the latter predominates except for fat and vitamin A.

The picture changes somewhat when the employment variable is observed in the home-produced nutrient equation (4.21). In this case F has a positive effect on all nutrients except carbohydrate, iron, and vitamin C. However, statistical precision is similar with t-values all below 0.5. The negative effect on iron and vitamin C could be due to decreased time available to spend growing and picking fruits and vegetables from the home garden.

Education

The education variables, E and E^2, had low t-values throughout the total and purchased nutrient equations. The expected results were positive E and negative E^2 to indicate an increase in nutrient consumption with initial increases in education then a decrease at some point. This is exactly what happens in the case of home-produced nutrients: all E terms are positive, all E^2 terms are negative. However, the magnitudes of the education terms are such that the total effect of education (not effect of E and E^2) is not negative within the relevant range of E values. This indicates that the quadratic form is reflecting a decreasing rate of increase in nutrient consumption with increasing education, rather than an absolute decline after a certain educational level. The t-values are all above 1.0 with ones of roughly 2.0 and above for calories, carbohydrate, iron, and vitamin C. Increases in education may result in the awareness of home grown fruits and vegetables as sources of vital nutrients, thus increasing iron and vitamin C intakes.

For purchased nutrients the predominant effect (for all except calories and carbohydrates) is the exact opposite: negative E terms, positive E^2 terms. This indicates a decrease in the purchase of nutrients with initial increases in education, then an increase after a certain point. These terms have small t-values with the exception of those for vitamin A. The magnitudes of the education terms are such that the total effect is positive by the fifth year of education except for iron, vitamin A, and fat.

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1 This assumes that the other head of the household is working as well.

In observing the effects of education on total nutrient consumption the results are mixed due to the varying influence of education on home versus purchased nutrients. The consumption of most nutrients is affected positively by education, at least initially. Vitamin A is affected negatively by education till the eleventh year. One supposition is that this reflects a "snob effect" away from greens (collard, spinach, turnip) which are a major source of vitamin A in the region. Since greens may be thought of as poor-people's food, the more educated a person becomes, the more likely they will try changing to other vegetables (possibly processed ones). These other vegetables may have more prestige value, but less vitamin A. In summary, the effects of education on home produced nutrients bodes well for increasing the consumption of certain nutrients through education aimed at encouraging home production and consumption.

Race

The race variable (defined as one when the household was white) was positive with high t-values for both total and home-produced nutrients. The effect of race on purchased nutrients was negative except for calcium, vitamin A, and vitamin C. These nutrients along with fat and iron had the highest t-values for race. The overall indication is that white households consume more of all nutrients than black households. White households have a proclivity to consume from home-produced nutrients, whereas black households tend to rely more on purchased nutrients (except for calcium, vitamin A, and vitamin C). This indicates that education aimed at production for home consumption of fruits and vegetables could be most valuable to black households.

Meal Adjustment

The meal adjustment variable (J) was designed to account for extra meals eaten within the household (i.e., guests) and meals eaten outside the household (i.e., skipped and restaurant meals). The variable is positive with high t-values in all cases. The positive sign is logical, indicating an increase in nutrient consumption with increased number of household meals. The variable was utilized largely to account for the effect of variance in total meals eaten within the household (since the dependent variable is defined as t tal nutrients eaten within the household), so as to more accurate y estimate the other variables.

Family Classification Variable

The family classification variable (C_j) was designed to account for the age-sex structure of the household. The coefficients were, with minor exceptions, positive as expected. Larger numbers of individuals in the household would logically increase total household consumption by some amount. The C_j in most all cases have t-values above 1.0 and usually in the range of 3.0 to 5.0. Thus, the statistical precision of these estimates is fairly high. If the coefficients of the C_j from the total nutrient consumption equation are assumed to

express the average intake of the j^{th} type of individual, then they can be compared with the Recommended Dietary Allowances (RDAs)[1] for the j^{th} type of individual. The C_j in the purchased and home-produced nutrient equations were utilized mostly to account for family structure, not to compare with RDAs. However, the coefficients of the C_j in the purchased nutrient equation (4.20), plus the respective C_j from the home produced nutrient equation (4.21), sum to roughly the C_j of the total nutrient equation. This indicates that the major source of a nutrient for an individual of type j can be discerned by comparing C_j coefficients from equations 4.20 and 4.21. These comparisons, as well as those of total nutrient intake to RDA, are presented in Table 5.11.

The results suggest that deficiencies may exist in all nutrients for some types of individuals. Calorie intakes are low for infants, children 4 to 6 years, teenagers of both sexes, and females over 51 years of age. Some of these results are questionable. In particular the infant coefficient has a low t-value indicating an imprecise estimate. Although the other predictions probably indicate problem individuals, a rapid drop in magnitude from the adjacent groups can indicate a possible error in grouping. That is, if the C_j groups are drawn too finely, the correlation of the two groups will be such to prevent the regression analysis from estimating separate coefficients precisely. For example, if the inclusion of a 15 to 18-year-old male has approximately the same impact as a 19 to 22-year-old on household consumption, then trying to discern two separate effects will only result in an imprecise estimate of one or both coefficients.

Protein intake seems low for infants and males 19 to 22 years, but both are questionable results for the reasons stated above. Calcium consumption appears low for both sexes, ages 4 through 18. The negative coefficient for infants may simply indicate the difficulty in assessing nutrient consumption of infants where breast feeding is not included. Iron intakes are low for infants and females 11 through 50 years of age. The infant intake is more reliable than that for calcium, since human milk is an insignificant source of iron. The low iron consumption of females is particularly obvious due to their higher requirements. Vitamin A intakes appear sufficient for all but females over 23 years. Riboflavin is low for infants and 4 to 6-year-olds, but these are possibly imprecise for the reasons ascribed to calorie and protein estimates above. Vitamin C consumption is low for infants through 6-year-olds and children 15 to 22.

The percentage of total nutrients from home production by type of individual indicates that a larger percentage of older people's consumption is from home production, than younger people's (Table 5.11). In particular, the oldest female age group obtains from 70 to 100 percent of their nutrients from home production. A caution

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1 See chapter 1 for a discussion of RDAs. Also, note that the coefficients are indicators of average intakes and as such imply that some people will be worse off.

TABLE 5.11

Classification Coefficients[a] and RDAs

Calories				
C_j	Coefficient	RDA	% of RDA	% of Home Prod.[b]
C1	(486)[c]	837	58	d
C2	1896	1300	146	23
C3	723	1800	40	8
C4	2727	2400	114	9
C5	4307	2800	154	21
C6	2875	3000	96	32
C7	1101	3000	37	3
C8	3838	2700	142	31
C9	3483	2400	145	37
C10	3079	2400	128	20
C11	1817	2100	87	6
C12	2760	2000	138	17
C13	2908	2100	138	39
C14	1660	1800	92	100

Protein (grams)				
C_j	Coefficient	RDA	% of RDA	% of Home Prod.
C1	(12)	16	75	65
C2	68	23	296	19
C3	31	30	103	7
C4	74	36	206	14
C5	116	44	264	24
C6	88	54	163	44
C7	37	52	71	32
C10	98	44	223	20
C11	54	48	112	12
C12	70	46	152	26
C15	94	56	168	46
C16	57	46	124	76

Vitamin A (I.U.)				
C24	3330	1800	185	11
C25	3280	2900	113	27
C26	4840	5000	97	36
C27	5060	4000	126	19
C15	5860	5000	117	60
C16	3190	4000	80	100

Vitamin C (milligrams)				
C28	12	38	32	0
C29	77	45	171	26
C30	36	45	80	12
C19	50	45	111	67
C20	58	45	129	93

TABLE 5.11 (continued)

Iron (milligrams)				
C_j	Coefficient	RDA	% of RDA	% of Home Prod.[b]
C1	9	13	69	2
C2	15	15	100	22
C3	10	10	100	20
C4	17	10	170	15
C21	22	18	122	31
C22	16	10	160	33
C23	14	18	78	11
C12	13	18	72	40
C13	13	18	72	47
C9	16	10	160	42
C14	10	10	100	99

Riboflavin (milligrams)				
C1	(0.4)	0.5	80	28
C2	1.8	0.8	225	23
C3	0.5	1.1	45	0
C4	1.6	1.2	133	7
C26	2.2	1.7	129	34
C27	1.5	1.4	107	9
C15	2.5	1.6	156	51
C16	1.1	1.1	100	97

Calcium (milligrams)				
C_j	Coefficient	RDA	% of RDA	% of Home Prod.
C1	(-159)[c]	450	d	d
C2	1119	800	140	26
C3	(50)	800	6	d
C4	718	800	90	18
C17	1087	1200	91	23
C18	833	1200	69	19
C19	888	800	111	37
C20	839	800	105	68

[a] The coefficients have all been divided by 7 to get a daily estimate of intakes.

[b] The % from home production was figured from the coefficient of home produced divided by the sum of the home produced and purchased coefficients.

[c] Parentheses on a coefficient indicate a t-value of less than 1.0.

[d] These values could not be determined or were meaningless due to a negative coefficient.

is necessary since the regression may simply be picking up a correlation between the presence of an older female and the existence of a kitchen garden for home produce. It is more likely that the older (more traditional) homemakers will have a garden. For calcium and vitamin C, some of the lowest intake to requirement ratios are associated with the lowest percentage of nutrients from home production. This may indicate that efforts to increase home production for consumption may not reach the at-risk groups for calcium and vitamin C. For iron and vitamin A the situation is not as clear-cut; home production could be a viable method for increasing consumption by the at-risk groups. However, a proviso is necessary since this model can say nothing about who will receive the most nutrients from an increase in home production, but only what appears to be happening now.

Each variable of the models has been discussed and the results derived contrasted between models. The results for the income, education, and family size-composition variables have been particularly informative. A brief discussion of the models as a whole follows.

The Models

The total nutrient consumption model had an adjusted coefficient of multiple correlation ($\bar{R}^2$) of approximately 0.50 or above except for calcium, vitamin A, and vitamin C. This is a fairly good $\bar{R}^2$ for cross-section data when utilizing individual households as observations. The total nutrient consumption approach can illustrate which socioeconomic variables affect nutrient consumption. The most useful aspect of this model might be to use the estimates of the classification coefficients to predict likely deficiencies within the household. Nutrition surveys on a person by person basis are expensive and time consuming. If this method provides a simple predictor of deficiencies amongst household members, it would be useful in nutrition planning. This is because a household can appear to have a sufficient per capita consumption, but be distributing it inequitably amongst the household members.

The two attempts (equations 4.19 through 4.21) to describe home as opposed to purchased nutrient consumption provided a general picture of the interactions between the two. Statistical problems still exist with these models. Particularly for the home production equation 4.21, the difficulty of several zero observations on the dependent variable was ignored. This probably caused the lower $\bar{R}^2$ and t-values for this model. If a simple estimate of how much home production was influencing the purchase of nutrients were desirable, the purchased nutrient equation (4.19) would be the best. The HCAL, HPRO, etc. variables of equation 4.19 give a direct estimate of the effect of increased home produced nutrients on purchases. The impact on purchased nutrients is negative with t-values above 2.0, except for carbohydrates. The implications are that a 1 percent increase in home produced nutrients decreases purchases by as little as 0.1 percent (vitamin A) to as much as 0.4 percent (protein). Thus, an increase in home-produced nutrients does not directly replace purchases,

which makes increases in home production an optimistic method for increasing total nutrient consumption.

The alternative model of home and purchased nutrients, equations 4.20 and 4.21, is valuable in its own way. The results of these two equations have illustrated the importance of observing the effects of variables on home and purchased nutrients separately. The coefficients of these two equations, in general, come close to summing to the respective coefficient of the total nutrient equation. In particular, the impact of income and education on total nutrients was indistinct until these equations were considered. It seems that the opposing reactions of home and purchased nutrients to these variables obscures their impact on total nutrients. Thus, as a means of discerning the interaction of home and purchased nutrients on all the variables, equations 4.20 and 4.21 are very useful.

Conclusions

In conclusion, the total nutrient model illustrates an important method for possibly determining intra-household distribution of nutrients. Secondly, it illustrates the low income elasticities of nutrients. The purchased nutrient model of equation 4.19 provided an estimate of how much purchased nutrients could be expected to decline with increases in home produced nutrients. The relatively low estimate gives encouragement to increasing nutrient consumption through home production. Equations 4.20 and 4.21 illustrate how important it is to observe the effects of socioeconomic variables on home and purchased nutrients separately. This is vital in order to more fully assess their impact on total nutrient consumption.

The importance of nutritional goals has been stressed in the early chapters. What is still in question at the end of this analysis is, how does an economist or planner actually predict policy needs and effects? The specific methodology utilized in chapter 4 has illustrated that it is applicable as a descriptive and prescriptive tool, but this is not all that is needed. A more specific predictor of policy effects is necessary as well. With the analysis above, it is possible to say encouragement of home production appears to have a bigger impact on nutrition than increases in income. However, no quantification of impacts can be achieved. A methodology to do this still needs to be developed. Those attempts of Pinstrup-Andersen (45) and Tyrrell (62) discussed in chapter 3 are good starts in this direction.

Nutritional well-being is a goal that will not be achieved by efforts solely to increase income (8).' Therefore, nutrition must be included either specifically or implicitly in the planning process. The first part of this process can be helped through the use of the methodology discussed in chapter 4. Probably the best way to take account of nutritional impacts is to consider the general consequences of development plans. That is, a narrow economic point of view of development plans is liable to obscure nutritional (or other important)

implications of policies. What is needed most is a desire and ability on the part of planners to pursue a holistic, interdisciplinary approach to development.

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